

Revised Response Action Work Plan

**Libby Railyard
Libby, Montana**

**The Burlington Northern and
Santa Fe Railway Company**

K/J 046022.11

August 2004

Kennedy/Jenks Consultants
Environmental Management Resources, Inc.

**REVISED RESPONSE ACTION WORK PLAN
THE BURLINGTON NORTHERN AND SANTA FE RAILWAY COMPANY
LIBBY RAILYARD ASBESTIFORM FIBER REMOVAL
LIBBY, MONTANA**

Prepared for

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EXECUTIVE SUMMARY

This Work Plan is intended to describe the Scope of Work for a planned Response Action at the Libby, Montana Railyard, herein referred to as the Site. The objective of this Response Action is the removal of Libby Amphibole from the surface of the Site, based on analytical data obtained from 2001 through 2004, and visual mapping of hydrated biotite that was mapped in October 2001.

The Response Action will consist of removing yard tracks from the Site, excavating soil containing Libby Amphibole from Site soil located beneath the footprint of Tracks 1, 2, and portions of Tracks 3,5, and the West Sidings, and capping soil containing Libby Amphibole at the remaining locations within the Site. After excavation, soil samples will be collected to evaluate whether Libby Amphibole is still present. Remaining material containing Libby Amphibole will be excavated. Soil will be transported in lined or covered dump trucks to the Lincoln County Landfill for disposal. Excavated areas will be backfilled with railroad subroadbed, and selected tracks will be reconstructed.

Dust suppression and air monitoring will be conducted during rail removal, excavation, backfilling, and soil capping operations.

The Site background is presented in Section 1.0 of this report. The Scope of Site Construction is outlined in Section 2.0, and the Sampling and Analysis Plan is outlined in Section 3.0. The following relevant documents are attached as appendices:

- A. *Asbestos and Other Fibers by PCM* (NIOSH Method 7400, Issue2, Revision 3)
- B. *AHERA TEM Method* (Appendix A to 40 CFR, Chapter 1, Part 763, Subpart E)
- C. *Asbestos (bulk) by PLM* (NIOSH Method 9002, Issue 2)
- D. *Asbestos Sampling* (EPA SOP 2015, Revision 0.0)
- E. *General Air Sampling Guidelines* (EPA SOP 2008, Revision 0.0)
- F. *Surface Soil Sampling* (CDM Federal SOP 1-3, Revision 4)
- G. *Field Logbook Content and Control* (CDM Federal SOP 4-1, Revision 4)
- H. *Sample Custody* (CDM Federal SOP 1-2, Revision 3)
- I. *Project-Specific Guidance Completion of Field Sample Data Sheets (FSDS)* (CDM Federal Document CDM-Libby-03, Revision 2)
- J. *Site-Specific Standard Operating Procedure for Soil Sample Collection* (CDM Federal Document CDM-Libby-05, Revision 1)
- K. *Sampling and Analysis – Non-mandatory* (U. S. Department of Labor, OSHA 29 CFR 1926.1101 Appendix B)
- L. Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)
- M. Asbestos Worker Protection; Proposed Rule: 40 CFR Part 763
- N. Key Personnel Resumes

Significant deliverables for this project are this Work Plan, a Health and Safety Plan, a Project Specification, a Draft Report, and a Final Report.

1.0 INTRODUCTION

Kennedy/Jenks Consultants and EMR, Incorporated (EMR) have prepared this Revised Response Action Work Plan (Work Plan) for The Burlington Northern and Santa Fe Railway Company (BNSF) to remove Libby Amphibole (tremolite/actinolite series) asbestos from the surface at the BNSF railyard in Libby, Montana, herein referred to as the Site. The Project Specifications prepared by Kennedy/Jenks Consultants in July 2004 and by EMR in July 2002 (revised in June 2004) should be referenced for information and requirements specific to this Work Plan. Kennedy/Jenks Consultants prepared Sections 1 and 2 of this Work Plan, and EMR prepared Section 3.

This Work Plan is based on EMR's October 2002 Final Remedial Action Work Plan, BNSF Libby Railyard Hydrated Biotite Removal, Libby, Montana.

All work in this Work Plan is to be completed by the end of December 2004, weather permitting, except that construction of replacement tracks may be conducted in the spring of 2005.

The Site location is shown on Figure 1. The Contamination Reduction Zone (CRZ) for proposed Site activities is shown on Figures 2, 3, 4, and 5. Figure 6 is a conceptual cross section showing proposed excavation and capping. Figures 7, 8, 9, and 10 show the areas of proposed excavation and capping.

1.1 BACKGROUND

The Libby Railyard was used historically to weigh and switch railroad cars used to ship hydrated biotite, which can contain asbestos including asbestiform fibers of tremolite, actinolite, richterite, and winchite, referred to in this document as Libby Amphibole. EMR previously mapped visible hydrated biotite mica in site soils as an anticipated visual indicator of Libby Amphibole. Subsequent laboratory sampling did not indicate a strong correlation between visible hydrated biotite mica and detectable Libby Amphibole. Therefore, additional sampling conducted in July 2004 will be combined with previous sampling conducted by EMR to define the area subject to surface soil excavation/capping. Figures 7, 8, 9, and 10 show the current understanding of the anticipated zone of excavation/capping, but they may be subject to modification based on soil sampling currently in progress. Track demolition and reconstruction may extend beyond the limits of the zone of excavation/capping due to engineering needs for track construction that are unrelated to surface soil removal.

Several options for this Response Action were evaluated in Kennedy/Jenks Consultants' June 2004 Evaluation of Conceptual Response Options, BNSF Railyard, Libby, Montana. The selected Response Action is a modification of Option 5 in that report. Option 5 has been modified to include the removal of Tracks 1, 2, 3, 4, a portion of Track 5, and the West Spurs. The footprint of Tracks 1, 2, the westernmost of the West Spurs, and portions of Tracks 3 and 5 will be excavated to remove soil containing Libby Amphibole and backfilled. The remaining surface soil containing Libby Amphibole (Track 4 and portions of Tracks 3 and the West Spur area) will be capped. Tracks 1, 2,

the removed portion of Track 5, and one of the West Spurs will be reconstructed. Details are provided in Section 2.0.

1.2 RESPONSE ACTION OBJECTIVES

The primary objective of this Response Action is to remove or cap surface soil within the Libby railyard that contains Libby Amphibole or visible hydrated biotite. Tracks will be removed to allow access to soil containing Libby Amphibole. After removal of soil containing Libby Amphibole, confirmation soil samples will be collected from the bottom of the removal area per Section 3.3 of this Work Plan and submitted for analysis of Libby Amphibole (tremolite/actinolite series) asbestos by PLM (Method 9002, Issue 2). Samples will be sent to EMSL Laboratories via CDM Federal Programs Corporation.

Following removal and capping activities, the railyard will be reconstructed in a configuration suitable for current railroad operations.

1.3 DIVISION OF WORK

Project construction is divided into three separate phases:

- Phase 1 – Rail demolition and tie removal.
- Phase 2 – Soil excavation/removal/capping for surface soil containing Libby Amphibole.
- Phase 3 – Track reconstruction.

Each phase has separate requirements for mobilization/demobilization and health and safety monitoring/personnel protection. Air monitoring will be conducted during Phases 1 and 2. Soil sampling to evaluate the effectiveness of the Response Action will be conducted during Phase 2. Because Site surface soil containing Libby Amphibole will be removed or capped with geotextile and imported fill prior to Phase 3, air monitoring and soil sampling will not be necessary during track reconstruction.

1.4 STAKING

EMR established the lateral extent of hydrated biotite and Libby Amphibole in Site soil, predominantly from visual inspection in October 2001 and from soil sampling and analysis using polarized light microscopy (PLM) and/or transmission electron microscopy (TEM). A grid system was established, and boundaries of visible hydrated biotite were staked with metal stakes. This grid system will be utilized to assist in defining the removal area in previously identified surface soils. Supplemental soil sampling and analysis conducted in July 2004 will be used to identify the western limit of the removal zone.

1.5 AGENCY OVERSIGHT

The United States Environmental Protection Agency (EPA) and its contractors will coordinate with BNSF, Kennedy/Jenks Consultants and EMR on a daily basis, and are responsible for regulatory oversight of the project. EPA is responsible for approval of this Work Plan and any pertinent changes to the Work Plan, in accordance with BNSF's Agreed Order on Consent (AOC) with EPA. EPA and its contractors may stop work if an unsafe condition is observed.

EPA and its contractors will have access to the site (with BNSF, Kennedy/Jenks Consultants and/or EMR representatives, except in the case of an emergency). In the case of an emergency when a representative of BNSF or its contractors is not on site, and EPA, its contractors, or City of Libby emergency personnel deem immediate access to the site is needed, the Agency representatives must immediately contact:

BNSF Environmental Resource Operations Center at 1-800-832-5452.

If the emergency occurs within 25 feet of an active track, it is paramount for the Agency representatives to call the Environmental Resource Operations Center at once, then make every reasonable effort to contact in-town representatives for BNSF and/or its contractors to meet at the site.

2.0 SITE CONSTRUCTION

Construction for Phases 1 and 2 will be conducted with Kennedy/Jenks Consultants providing a Resident Engineer on behalf of BNSF. EMR will provide asbestos oversight: conduct air monitoring, visual inspection, confirmation sampling, and monitor for visible dust or particle emissions. EMR will complete the Daily Soil Removal Report and Daily Safety Report with assistance from the Resident Engineer. GPS readings and the grid established in October 2001 will be used to determine the location of soil removal, and this information will be recorded on the Daily Soil Removal Report.

BNSF or a separate contractor will perform Phase 3 track reconstruction using its standard supervision and safety procedures for railroad construction. No special health and safety precautions will be required during track reconstruction because soils containing Libby Amphibole will have been removed or contained beneath a geotextile fabric and imported fill cap.

2.1 PHASE 1: RAIL DEMOLITION

2.1.1 Surveying/Staking

Prior to rail removal, the lateral extent of rail removal will be identified on the design drawings and marked in the field by painting marks on rails at the limits of removal.

2.1.2 Mobilization

The Site will contain an Exclusion Zone (EZ) and CRZ. The EZ is the area where work is taking place. These areas will be considered the EZ until Phase 2 work is conducted as described below. The CRZ includes the personnel decontamination trailer and equipment decontamination facilities. The EZ will be demarcated with signage and caution tape and/or yellow or white traffic cones. If signage is used, the following language will be on the signs:

“DANGER ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTION CLOTHING ARE REQUIRED
IN THIS AREA”

The EZ is also the regulated area where Phase 2 soil removal activities occur. Employees must wear modified Level C personnel protective equipment (PPE) and all BNSF PPE inside the EZ.

A CRZ will be established outside the EZ. Demolition will be conducted so that this zone will consist of the area between the EZ and decontamination facilities. A linear corridor of traffic cones from the EZ to the decontamination facilities will be established for personnel to pass between the EZ and decontamination facilities. The northern

boundary of the CRZ will be the property boundary during the demolition phase. The CRZ will contain the personnel three-stage decontamination trailer equipment room (dirty room, shower, and clean room). The personnel decontamination facilities will be located east of the highway overpass and scale house on the northern side of the tracks. Personal decontamination procedures are outlined in Section 2.1.1 of Volume III, Libby Amphibole Health and Safety Plan (HASP).

Decontamination of rail and associated metallic appurtenances will be conducted within the EZ. Therefore, residual material removed from the metallic materials will remain within the zone of Phase 2 work and will be subsequently excavated or contained beneath a geotextile and imported fill cap.

The decontamination pad will be within the CRZ. All equipment, including vehicles, leaving the CRZ will be decontaminated as described in Section 2.1.2 of the HASP. The EMR representative for BNSF will verify that the equipment has been cleaned. The equipment decontamination pad will be located east of the highway overpass on the northern side of the tracks.

The project Site (or clean zone) outside the CRZ consists of the rest of the BNSF right-of-way and City of Libby property requires modified Level D PPE and all BNSF PPE.

Due to railroad engineering considerations, some rail demolition may occur outside the area of surface soil containing Libby Amphibole. Those areas are not considered to be within the EZ, and the contractor will need to take suitable precautions to prevent cross-contamination from areas where soil contains Libby Amphibole.

An activity hazard analysis will be conducted before work begins. A health and safety briefing discussing the findings of the activity hazard analysis will then be conducted. Daily safety briefings will occur before work begins. Any person new to the Site after the daily briefing will need to meet with a Kennedy/Jenks Consultants or EMR supervisor for a safety briefing. All work will be conducted in accordance with the Site HASP.

2.1.3 Demobilization

After the rail demolition is completed, the equipment will be decontaminated as described in Section 2.1.2 of the HASP. The EMR representative for BNSF will verify that the equipment has been cleaned. The equipment decontamination pad will be located east of the highway overpass on the northern side of the tracks.

2.1.4 Site Preparation

2.1.4.1 Utility Location. The contractor will schedule and perform a utility locate through the Montana One Call system prior to beginning work in order to determine whether any utilities will need to be addressed during removal activities. In addition, the contractor will conduct supplemental utility location through BNSF and private utility locating services.

2.1.4.2 Asbestos Notification. The demolition contractor will conduct all necessary asbestos notifications and secure any permits required from local, state, and federal agencies. If notification to the State of Montana is not necessary, a courtesy notification should still be conducted.

2.1.5 Scope of Demolition

Rails from Tracks 1, 2, 3, 4, the West Spurs, and a portion of Track 5 will be demolished as shown on Figures 2, 3, 4, and 5. Removal will include rails, tie plates, spikes, joint bars, bolts, and all other metallic appurtenances. Ties may be removed and loaded directly into lined railcars, or they may be decontaminated and transported off site. The Scale Pit on Track 4 will be decontaminated or demolished and disposed as asbestos-containing material, the scale mechanism removed, and the pit backfilled with sand or rock.

Rail will be pressure washed in the immediate vicinity of the point of removal and removed from the site.

Railroad ties within the zone of excavation (Zone 1/2/3) will be removed from the ground. Ties will either be loaded directly into lined containers and shipped to a suitable landfill, or decontaminated in the immediate vicinity of removal, and then removed from the site for disposal. If decontamination is selected, it will be accomplished by pressure washing to remove residual soil and Libby Amphibole. All four sides and the ends of the ties will be washed; each side will be thoroughly sprayed from one end to the other. The contractor has a conveyor device specifically constructed to pressure-wash ties. The ties are pulled through a series of pressure nozzles facing all sides, and hand-directed washing is available at the end of the belt when needed. The visible soil and debris will be removed. Decontamination water will be allowed to infiltrate within the soil near the point of removal, and the soil will subsequently be excavated or capped as described below.

If railroad ties are decontaminated, they will either be stockpiled in a clean area for later disposal or will be loaded directly into trucks or railroad cars. BNSF will dispose of the ties at a tie disposal facility. The likely disposal method will either be chipping and incineration or incorporation into a suitable landfill. Any ties that are reloaded into lined railcars without decontamination will be disposed into a suitable landfill. The ties will not be sold or reused.

Dust suppression procedures are outlined in Section 2.2 of the HASP.

2.2 PHASE 2: EXCAVATION, REMOVAL AND CAPPING

2.2.1 Surveying/Staking

Prior to excavation, the limits of excavation will be staked based on the existing sample data and results from the July 2004 sampling event. Figures 6, 7, 8, and 9 depict the limits of excavation as they are understood at the time of the creation of this work plan.

2.2.2 Mobilization and Setup

The site will contain an EZ and CRZ as described in Section 2.1.2. The EZ is the area where cleanup takes place. After cleaning, these areas will also be considered to be EZs until soil sampling results do not detect Libby Amphibole or the cap is constructed. The CRZ includes the personnel decontamination trailer and equipment decontamination facilities. The EZ will be demarcated with signage and caution tape and/or yellow or white traffic cones. Signage will be placed, at a minimum, inside the decontamination trailer, at the entry/exit points to the EZ and at the perimeter boundaries. The following language will be on the signs:

“DANGER ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTION CLOTHING ARE REQUIRED
IN THIS AREA”

The EZ is also the regulated area where soil removal activities occur. Employees must be in modified Level C personal protective equipment (PPE) with all BNSF PPE inside the EZ.

A CRZ will be established outside the EZ. The limits for the Phase 2 CRZ are shown on Figures 2, 3, 4, and 5. The CRZ will contain the personnel decontamination trailer as described in Section 2.1.1. Personnel decontamination procedures are outlined in Section 2.1.1 of the HASP.

The vehicle decontamination area will be within the CRZ as described in Section 2.1.2. The truck scale will be located outside the CRZ.

The project site (or clean zone) outside the CRZ consists of the rest of the BNSF right-of-way and requires modified Level D PPE and all BNSF PPE.

An activity hazard analysis will be conducted before work begins. A health and safety briefing discussing the findings of the activity hazard analysis will then be conducted. All work will be conducted in accordance with the Site Health and Safety Plan.

2.2.3 Demobilization

After surface soils containing Libby Amphibole are removed from the Site or capped in place, the equipment will be decontaminated as described in Section 2.1.2 of the HASP. The EMR representative for BNSF will verify that equipment has been cleaned. The equipment decontamination pad will be located as described in Section 2.1.2.

2.2.4 Site Preparation

Utility location and asbestos notification will be conducted by the Phase 2 contractor as described in Section 2.1.4 of this report.

2.2.5 Scope of Excavation, Backfill, and Cap Installation

Site soil will be excavated or covered with a geotextile fabric and imported fill as shown on Figures 7, 8, 9, and 10. Soil within Zone 1/2/3 will be excavated to remove detectable Libby Amphibole. Soil within Zones 4 and 6 will be capped in place with geotextile and imported fill. Soil within Zone 5 will be excavated where Libby Amphibole is present. A conceptual cross section of excavation and capping is shown on Figure 6. The approximate areas to be excavated or capped are shown on Figures 7, 8, 9, and 10. Dust suppression procedures are outlined in Section 2.2 of the HASP.

2.2.5.1 Zone 1/2/3. After removal of railroad ties, soil in Zone 1/2/3 will be excavated using a backhoe/trackhoe with a straight edged bucket. Conventional construction equipment can be used for loading and spreading. Soil containing Libby Amphibole will be excavated and placed in lined dump trucks for transport to the Lincoln County Landfill. Excavation and truck lining procedures will be conducted in accordance with EMR's Volume II, Project Specification, BNSF Libby Railyard Hydrated Biotite Removal, Libby, Montana, dated July 2004. Care must be taken to ensure that clean areas do not become contaminated again as a result of site activities. Clean areas shall be marked with paint, lathe, or other means to ensure that site workers are aware of which areas have already been cleaned to depth or capped. All work will proceed from clean to dirty areas.

The depth of excavation is anticipated to range from approximately 6 inches to 18 inches below ground surface. The practical vertical limit of excavation will probably be a tan clay layer that is believed to represent native soil. It reportedly occurs at a depth ranging from 8 inches below ground surface near the eastern end of the railyard to 18 inches at the western limit of the probable excavation. Therefore, an average depth of 1.0 to 1.25 feet of soil will likely be removed. Following excavation to the anticipated depth at which soil containing Libby Amphibole has been removed, confirmation sampling will be conducted in accordance with Section 3.0.

After confirmation sampling, in areas where soil containing Libby Amphibole has been removed, some additional clean soil may be removed to allow placement of a desired thickness of railroad sub-ballast backfill material. Clean soil removed by such over-excavation will be disposed as general fill, possibly elsewhere on BNSF property or at the Lincoln County Landfill.

2.2.5.2 Zone 5. Soil or gravel in Zone 5 that contain Libby Amphibole will be excavated in accordance with EMR's specifications as identified in Section 2.2.5.1. Excavated soil will be replaced with clean backfill similar to the material used to cap Zones 4 and 6 as identified below.

2.2.5.3 Backfill. The Zone 1/2/3 excavation will be backfilled with structural fill that meets BNSF requirements for railroad sub-ballast. Backfill will be obtained from a local source that meets EPA requirements to document absence of Libby Amphibole within the backfill material. Backfill will be compacted to standard railroad specifications for sub-ballast. The depth of backfill material will be sufficient to provide a final grade that allows for placement of ballast and track, while maintaining adequate vertical clearance between the tops of the reconstructed rails and the bottom of the Highway 37 overpass or other structures that overlie the rails. The minimum allowable vertical clearance is 23.5 feet above the top of the rail. Figure 6 shows the current vertical clearances beneath the Highway 37 overpass, but these will likely be different after construction is completed. The final requirements for clearances and, therefore, the appropriate final grade of backfill, will be identified in the final design drawings and specifications.

2.2.5.4 Cap Installation. Zone 4 and 6 soil containing asbestiform fibers will be capped in place. Railroad ties will be left in place, and the surface to be capped will be covered with geotextile meeting BNSF specifications for ultraviolet light-resistant, 12-ounce non-woven geotextile. The geotextile will be covered with 12 inches of capping material consisting of either sub-ballast or crushed rock meeting Montana Highway Department specifications for road sub-grade material.

Dust suppression procedures are outlined in Section 2.2 of the HASP.

2.3 PHASE 3: TRACK RECONSTRUCTION

Track reconstruction will not be conducted until Phase 2 work has been completed in the area where track will be reconstructed. Depending upon weather conditions at the conclusion of Phase 2 work, Phase 3 work may not be initiated until the following spring. BNSF personnel will perform track reconstruction.

2.3.1 Surveying/Staking

Upon completion of Phase 2 work, the centerlines of the tracks to be constructed will be surveyed and marked using surveyor's whisksers.

2.3.2 Mobilization

BNSF track-laying personnel will mobilize and set up using their normal procedures. No EZ or CRZ will be necessary because Site soil containing Libby Amphibole will have already been removed or capped. Track construction will occur only in areas where soil removal has been completed. No track will be constructed in capped areas.

2.3.3 Demobilization

BNSF track-laying personnel will demobilize and set up using their normal procedures. No decontamination procedures will be necessary because Site soil containing asbestiform fibers will have already been removed or capped.

2.3.4 Site Preparation

Track will be reconstructed over clean subgrade material placed during Phase 2 work. Utility location will be performed as described in Section 2.1.4. No asbestos notifications will be required.

2.3.5 Scope of Track Reconstruction

Tracks will be reconstructed at the approximate locations of existing Track 1, Track 2, one West Spur, and the portion of Track 5 that will be removed. BNSF will use materials suitable for future use of those tracks according to the Railroad's operational and engineering needs. Current plans call for installation of previously used concrete ties and previously used 136 pound per yard ribbon rail. Four switches will be replaced with 136 pound per yard rail. The West Spur and replaced portion of Track 5 will be constructed with similar rail and ties or new wood ties and rail consistent with the size on the remainder of each spur track. The approximate alignment of the reconstructed tracks will be the same locations for Tracks 1, 2, 5, and the westernmost of the West Spurs as shown on Figures 2, 3, 4, and 5.

Track will be constructed by placing concrete ties and rails on the subgrade material. BNSF will import suitable ballast material in hopper cars from sources located outside the Libby area. The ballast will be dumped on the track structure. The ballast will be tamped around the ties and the rail structure raised in 2-inch lifts until the desired thickness of ballast is achieved. Standard ballast placement and track lining equipment will be used.

Dust suppression will not be necessary for health reasons associated with Libby Amphibole because the ballast will be from a source that is distant from the Libby area (likely from the Cactus Pit at Sprague, Washington). The ballast will be dumped over clean subgrade material that does not contain Libby Amphibole.

2.4 FINAL SITE RESTORATION

BNSF will accomplish final site restoration, which will consist of placement of fresh railroad ballast material over the removal areas and grading as necessary.

2.5 SCHEDULE

The currently anticipated project schedule is as follows:

- 28 July 2004 – Prebid conference and site visit
- 12 August 2004 – Bid Opening Date
- 18 August 2004 – Notice to Proceed to rail removal contractor
- 2 September 2004 – Begin rail removal
- 7 September 2004 – Anticipated start of tie removal, soil excavation, cap installation and subgrade backfill.
- 19 November 2004 – Anticipated conclusion of tie removal, soil excavation, cap installation and subgrade backfill, weather permitting.
- Spring 2005 – Reconstruction of designated tracks.

2.6 REPORTING AND COORDINATING ACTIVITIES

Progress reports will be submitted to USEPA weekly by EMR with assistance from the Kennedy/Jenks Consultants Resident Engineer. The report will follow a standard format that consists of the following topics:

- Progress made during reporting period
- Problem areas and resolved/recommended solutions
- Deliverables submitted
- Activities planned for the next reporting period
- Key personnel changes, if any
- Sampling/lab activities

3.0 SAMPLING AND ANALYSIS PLAN

The standard operating procedures (SOPs) and project specific methods for sampling, sample control, and other site activities were adopted from the *Final Draft Response Action Sampling and Analysis Plan (RASAP) for Libby Asbestos Site* prepared by the CDM Federal Programs Corporation in November 2003 which is included in the *Final Draft Response action Work Plan for Libby Asbestos Project* prepared by the USEPA in November 2003. The following SOPs and Project Specific documents will be utilized for project activities including soil and air sampling:

- *Asbestos and Other Fibers by PCM* (NIOSH Method 7400, Issue 2 Revision 3);
- *AHERA TEM Method (Appendix A to Subpart E of Part 763 – Interim Transmission Electron Microscopy Analytical Methods – Mandatory and Non-mandatory – and Mandatory Section to Determine Completion of Response Action) (40 CFR – Chapter I – Part 763)*
- *Asbestos (bulk) by PLM* (NIOSH Method 9002, Issue 2)
- *Asbestos Sampling* (EPA SOP 2015, Revision 0.0)
- *General Air Sampling Guidelines* (EPA SOP #2008, Revision 0.0)
- *Surface Soil Sampling* (CDM Federal SOP 1-3, Revision 4)
- *Field Logbook Content and Control* (CDM Federal SOP 4-1, Revision 4)
- *Sample Custody* (CDM Federal SOP 1-2, Revision 3)
- *Project-Specific Guidance Completion of Field Sample Data Sheets (FSDS)* (CDM Federal Document CDM-Libby-03, Revision 2)
- *Project-Specific Standard Operating Procedure for Soil Sample Collection* (CDM Federal Document CDM-Libby-05, Revision 1)
- *Sampling and Analysis – Non-mandatory – U. S, Department of Labor, OSHA 29 CFR 1926.1101 Appendix B.*

The EPA has adopted modifications to these procedures that are discussed in the text of Appendix A of the RASAP in a section titled Confirmation Soil Sampling Procedures; this work plan will utilize the modifications included in that section. Additional modifications to those project specific methods or SOPs are discussed in this work plan.

3.1 SAMPLE CUSTODY, DOCUMENTATION, PACKAGING, AND SHIPPING

Sample custody includes the identifying, labeling, packaging, and transporting of samples collected during this investigation. The chain-of-custody record is used as physical evidence of sample custody and control and provides the means to identify, track, and monitor each individual sample from the point of collection through final data reporting. Each sample will be identified by a unique code as provided by EPA's agent, CDM Federal Programs Corporation (CDM Federal). Sample details will be noted in the sampling log sheets and field logbooks. These activities will be conducted in accordance with the SOPs and guidance documents: *Field Logbook Content and Control, Sample Custody, and Project-Specific Guidance Completion of Field Sample Data Sheet* except as noted below.

SOP 4-1 specifies that a specific document control number will be utilized. A specific document control number will not be required; however the book will be labeled with a project name and the date range contained within. For any reference made to document or sample retention by CDM or shipment to CDM it should be noted that records for the BNSF project will be maintained by EMR instead of CDM. Copies of lab data analyzed by EMSL will be supplied to the EPA and their designated recipients upon receipt of final copies. EMSL will supply data to EMR in a format compatible with the EPA database. EMR will use chain-of-custody forms supplied by either CDM Federal, Volpe, or the laboratory.

3.2 AIR MONITORING

Personal air samples will be collected inside the EZ with a low-volume battery pump for each person sampled following Sampling and Analysis – Non-mandatory (29 CFR 1926.1101 Appendix B) and Asbestos Sampling SOP 2015. The samples will consist of a 30-minute excursion sample and sampling representative of full shift exposure. Samples will be analyzed using the NIOSH Method 7400 PCM, Issue 2 (Appendix A). The action level for which corrective action will take place inside the EZ is 0.1 f/cc. This corresponds to the OSHA permissible exposure limit (PEL) criteria for work in an environment with no respiratory protection. Some samples will also be submitted for analysis by AHERA TEM method (TEM). Any samples exhibiting concentrations exceeding 0.1 f/cc will be analyzed by TEM; if no samples exceed 0.1 f/cc then the tables below will be utilized to determine the number of samples to be submitted to the laboratory. A minimum of 3 samples will be submitted for TEM analysis daily.

On the first full day of soil removal the following samples are anticipated in the EZ from the breathing zone of the workers:

Table 1

Description of Function	Description of Sample Types	Number of Samples	Analysis	Total Number of Samples
Equipment Operator*	Representative of full-shift exposure	2 per person	PCM and 50% TEM	2 PCM, 1 TEM
	Excursion	1 per person	PCM and TEM	1 PCM, 1 TEM
Spotter, Wrapper, or other ground personnel*	Representative of full-shift exposure	2 person	PCM and 50% TEM	2 PCM, 1 TEM
	Excursion	1 person	PCM and TEM	1 PCM, 1 TEM
One Truck Driver	Representative of full-shift exposure	2 daily	PCM and 50% TEM	2 PCM, 1 TEM
	Excursion	1 daily	PCM and TEM	1 PCM, 1 TEM
Total Number of Anticipated Samples for the First Day				9 PCM, 6 TEM

For subsequent days of site work we anticipate that the following breathing zone samples will be collected from EZ workers:

Table 2

Description of Function	Description of Sample Types	Number of Samples	Analysis	Total Number of Samples
Equipment Operator*	Representative of full-shift exposure	2 per person	PCM and TEM	3 PCM, 1 TEM
	Excursion	1 per person	PCM and TEM	
Spotter, Wrapper, or other ground Personnel*	Representative of full-shift exposure	2 per person	PCM and TEM	3 PCM, 1 TEM
	Excursion	1 per person	PCM and TEM	
One Truck Driver	Representative of full-shift exposure	2 daily	PCM and TEM	3 PCM 1 TEM
	Excursion	1 daily	PCM and TEM	
Daily Total Number of Anticipated Samples (After the First Day)				9 PCM, 3 TEM

* Estimates are for a crew of eight or fewer people inside containment. Air samples will be collected from a minimum of 25% of the workers inside of the EZ.

Five background ambient air samples will be collected roughly equidistant across the length of the yard the day before the scheduled start of the project. The pumps used for the project will be A.P. Buck Basic-12 battery-operated high volume pumps. These pumps have a capability to pull approximately 6 liters per minute over a 10-hour time period.

Ambient air samples during the removal action will be collected at five perimeter-monitoring sites per exclusion zone utilizing Asbestos Sampling SOP 2015 and EPA Guidelines SOP 2008. If possible only one exclusion zone should be established each day. If multiple exclusion zones are established, then five samples will be collected at each zone.

Air samples will be collected daily at the perimeter of the EZ. Five locations will be placed equidistant around the EZ. The samples will draw a minimum of 1,200 liters of air to achieve the desired minimum detection limits.

Historical wind direction data for Libby, Montana, is to the south. The actual locations of perimeter air samples will be selected in the field and surveyed using a GPS instrument and indicated on the Site map. Ambient air samples will be submitted to EMSL Laboratories for analysis by TEM Asbestos Hazard Emergency Response Act (AHERA) Method. If two fibers are identified on samples analyzed by TEM AHERA, site operations and engineering controls will be reevaluated.

3.3 SYSTEMATIC SOIL SAMPLING

Surface soil samples will be collected utilizing Surface Soil Sampling SOP 1-3, Revision 4 and Confirmation Soil Sampling Procedures from Appendix A of the RASAP.

As shown on the figures in Section 2.0, Libby Amphibole is present along portions of the rail lines. Following the removal action, discrete soil samples will be collected at 50-foot intervals along the rail lines, and a portion of four such samples will be composited; sample areas will be 200 feet or less in length and approximately 15 feet wide (i.e., one composite sample per 200 feet of track length) and sent or delivered to EMSL Laboratories for analysis. At each sample location, a metal nail with yellow plastic flagging will be driven into the ground. Soil samples will be collected with a stainless steel trowel or other appropriate sampling equipment as discussed in the SOP and Confirmation Soil Sampling Procedures. Samples will be placed in quart-sized resealable plastic bags (two per sample). Discrete samples will be submitted to the laboratory and held pending results of the composite samples. Discrete samples may be analyzed if the corresponding composite sample is positive for asbestos (Libby Amphibole detected).

Should any detectable Libby Amphibole (tremolite/actinolite series) by the PLM method 9002, Issue 2 (Appendix C), be observed in composite samples, the discrete samples may be analyzed to determine which discrete samples within the composite set that exhibits detectable concentrations of Libby Amphibole.

These areas will be excavated again in a 25-foot radius around the sample locations with detectable results, excluding areas sampled previously without detecting Libby Amphibole.

- Each sample point will be located by GPS. An electronic map of the main line, associated tracks, buildings, and roads will be constructed to scale, and the sample locations will be shown on the map.

Sample preparation by the laboratory will follow USEPA Region 8 standards for homogenizing surface soil samples. Soil samples will be analyzed using a PLM method 9002, Issue 2, analytical method (Appendix C).

3.4 SOIL CHARACTERIZATION SAMPLING

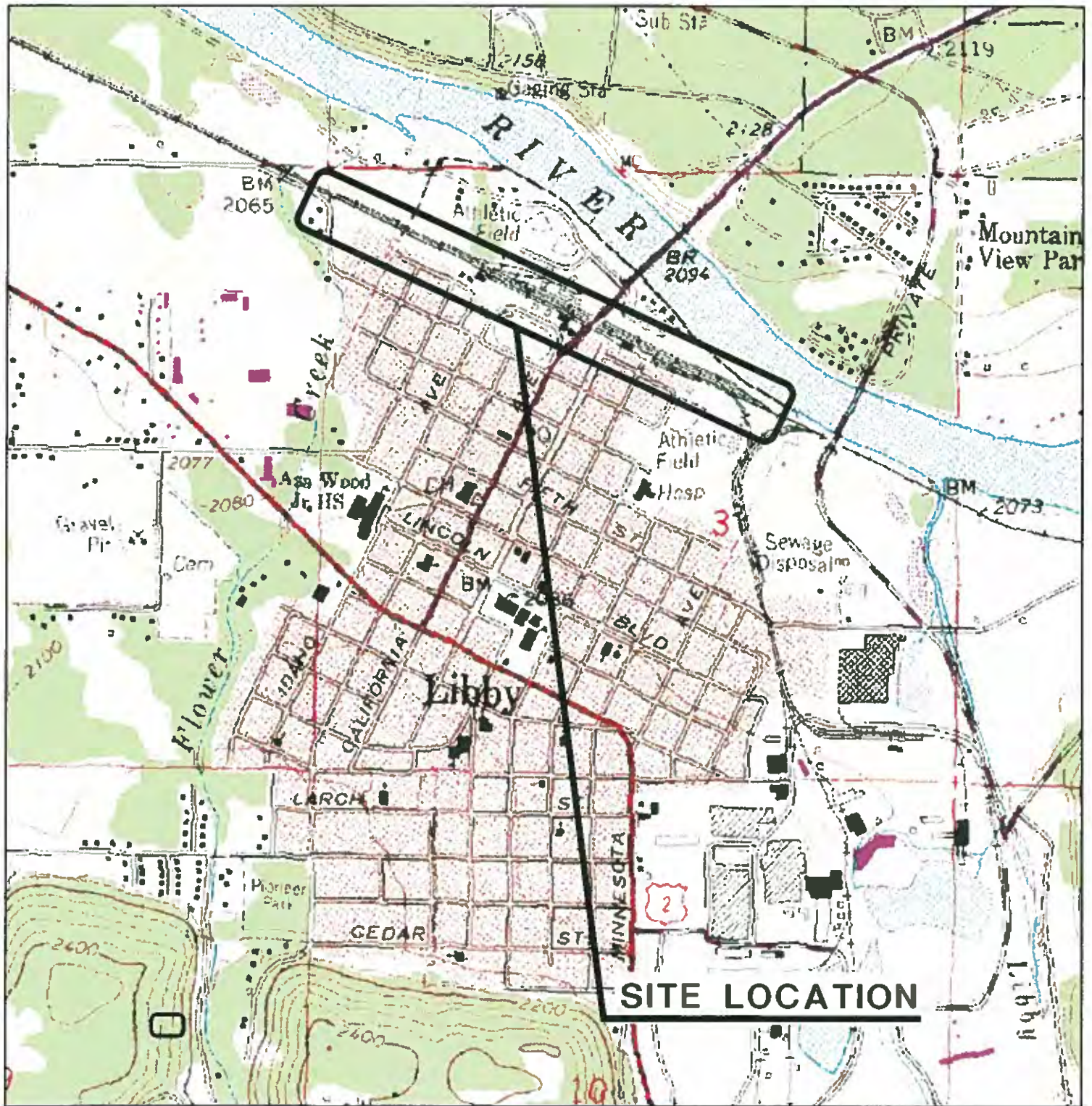
Required soil characterization samples were collected and the soils were profiled into the Lincoln County Landfill utilizing that sample data in 2003.

3.5 OPERATION AND MAINTENANCE ACTIVITIES

All known areas containing soil with Libby Amphibole will be removed or capped with geotextile cloth and fill material. Assuming all final soil confirmation samples collected from excavation areas do not indicate the presence of Libby Amphibole, and for the purposes of this Response Action, no additional remedial activities are anticipated at this time. BNSF will prepare an Operations and Maintenance Plan for the Zone 4 and 6 areas, which will receive the cap.

Figures





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LIBBY, MONTANA

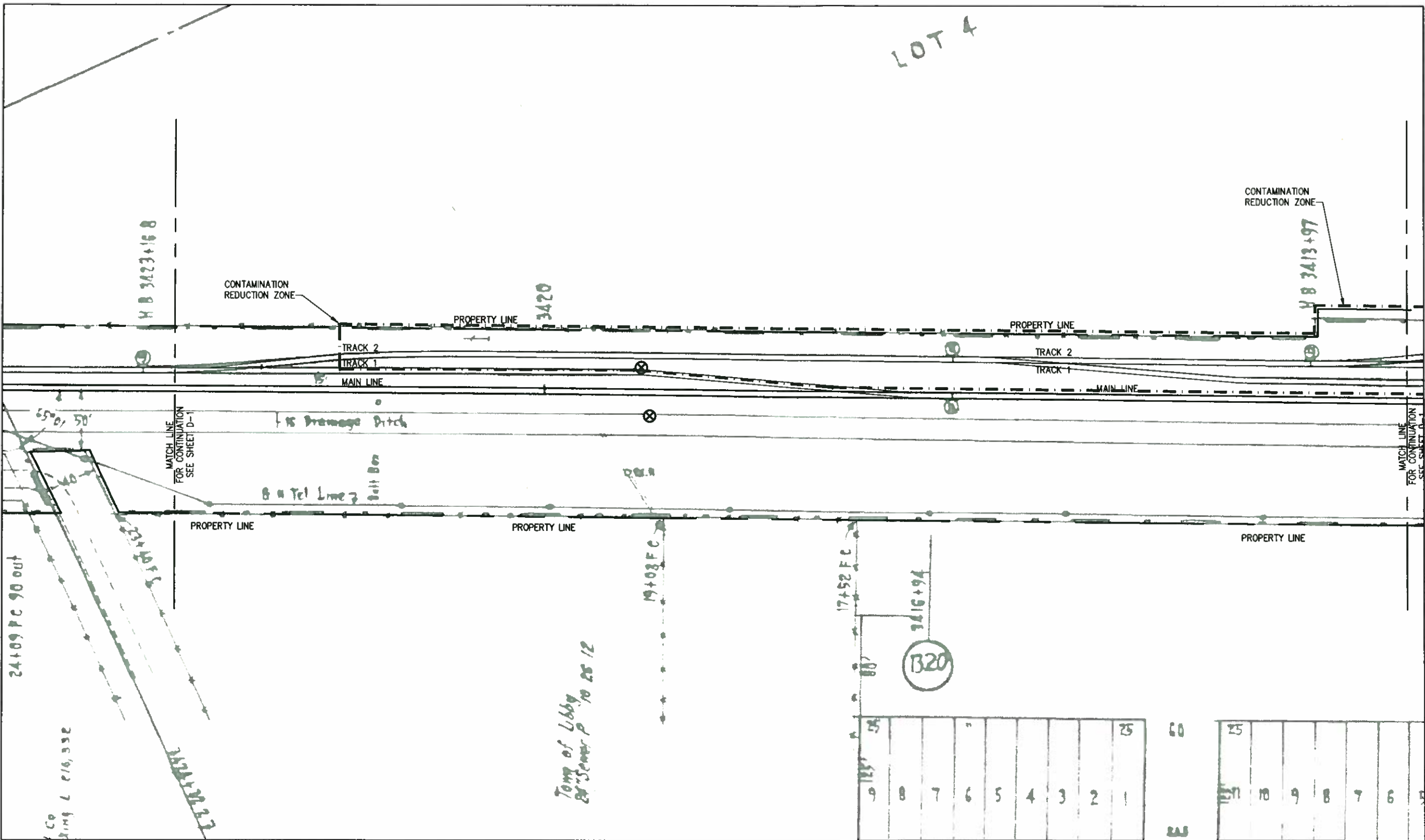
SITE LOCATION



NOT TO SCALE

046022.11/P04SK001

FIGURE 1



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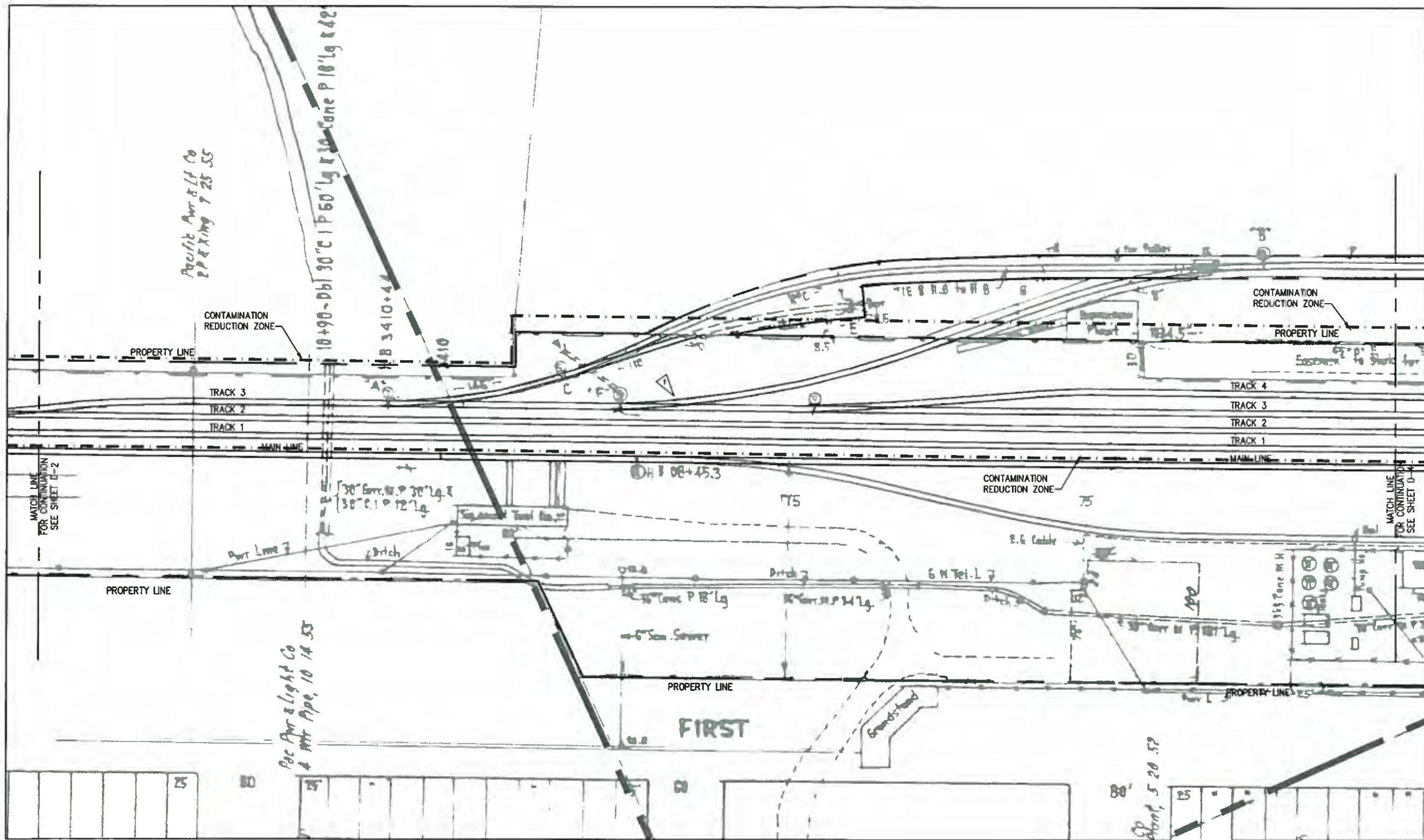
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PHASE 1 & 2
CONTAMINATION REDUCTION ZONE

046022.11/P04SK002

FIGURE 2





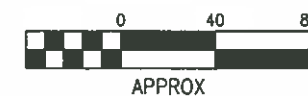
Kennedy/Jenks Consultants

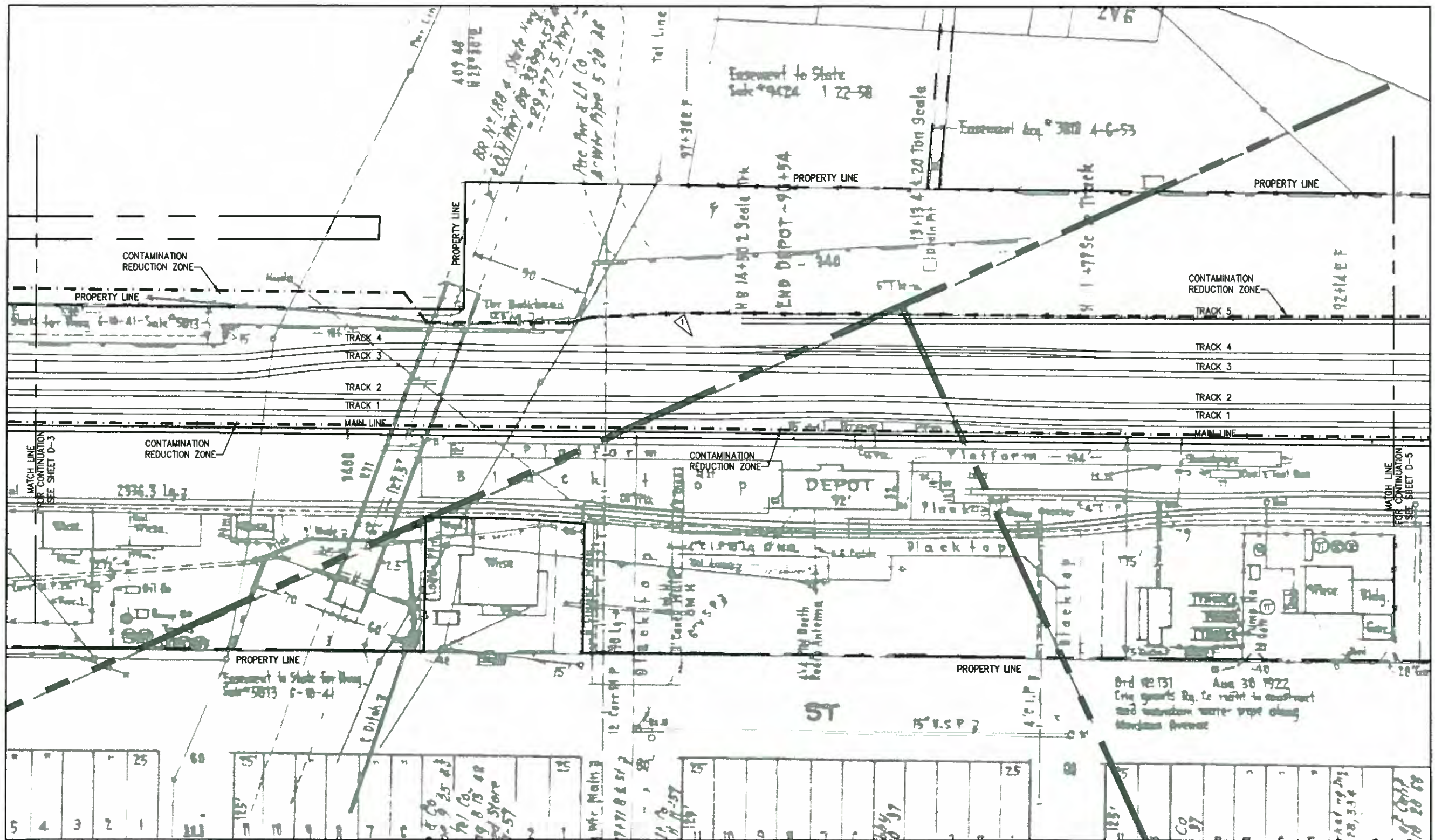
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PHASE 1 & 2
CONTAMINATION REDUCTION ZONE

046022.11/P04SK003

FIGURE 3





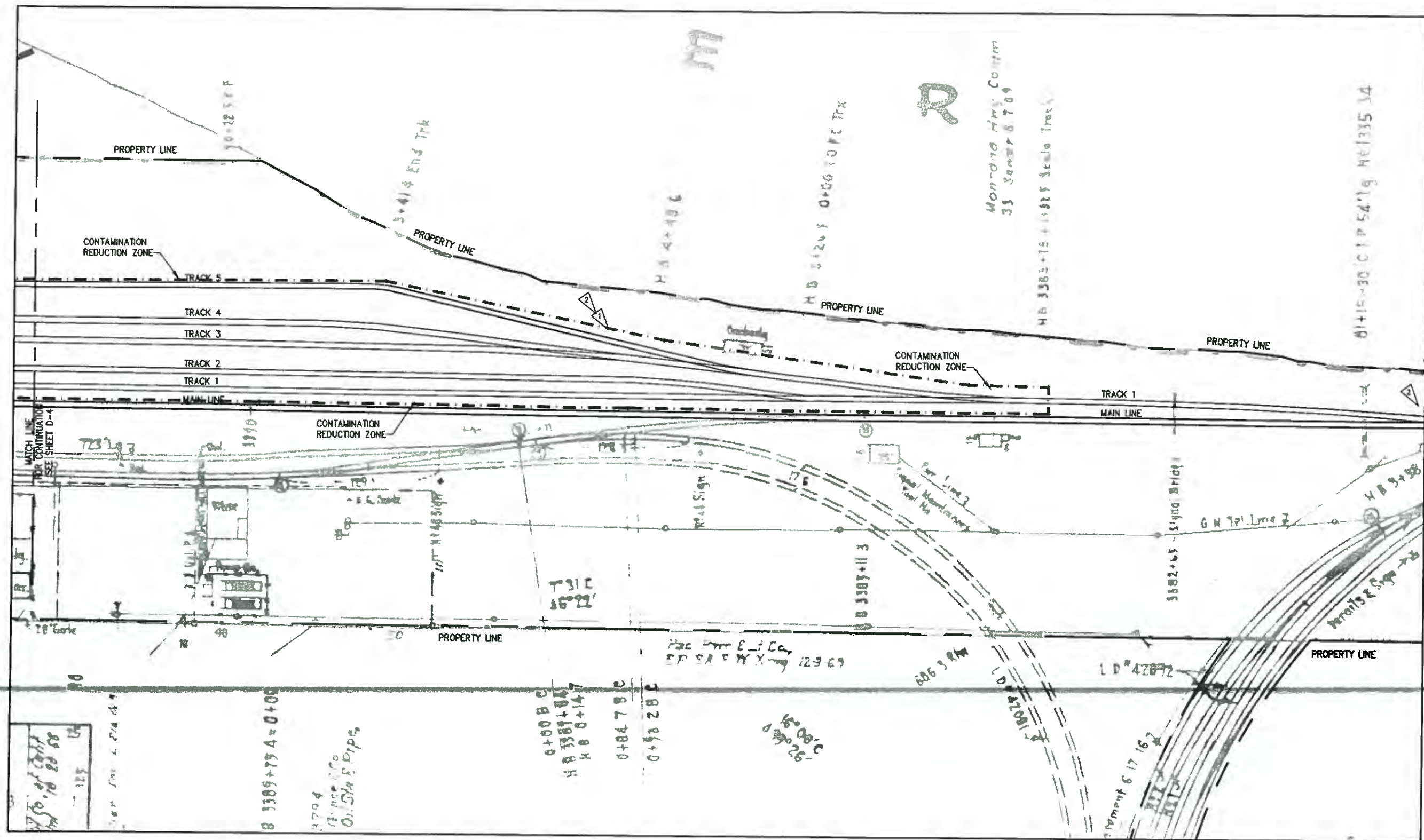
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**PHASE 1 & 2
CONTAMINATION REDUCTION ZONE**

046022.11/P04SK004

FIGURE 4



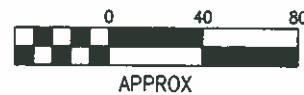
Kennedy/Jenks Consultants

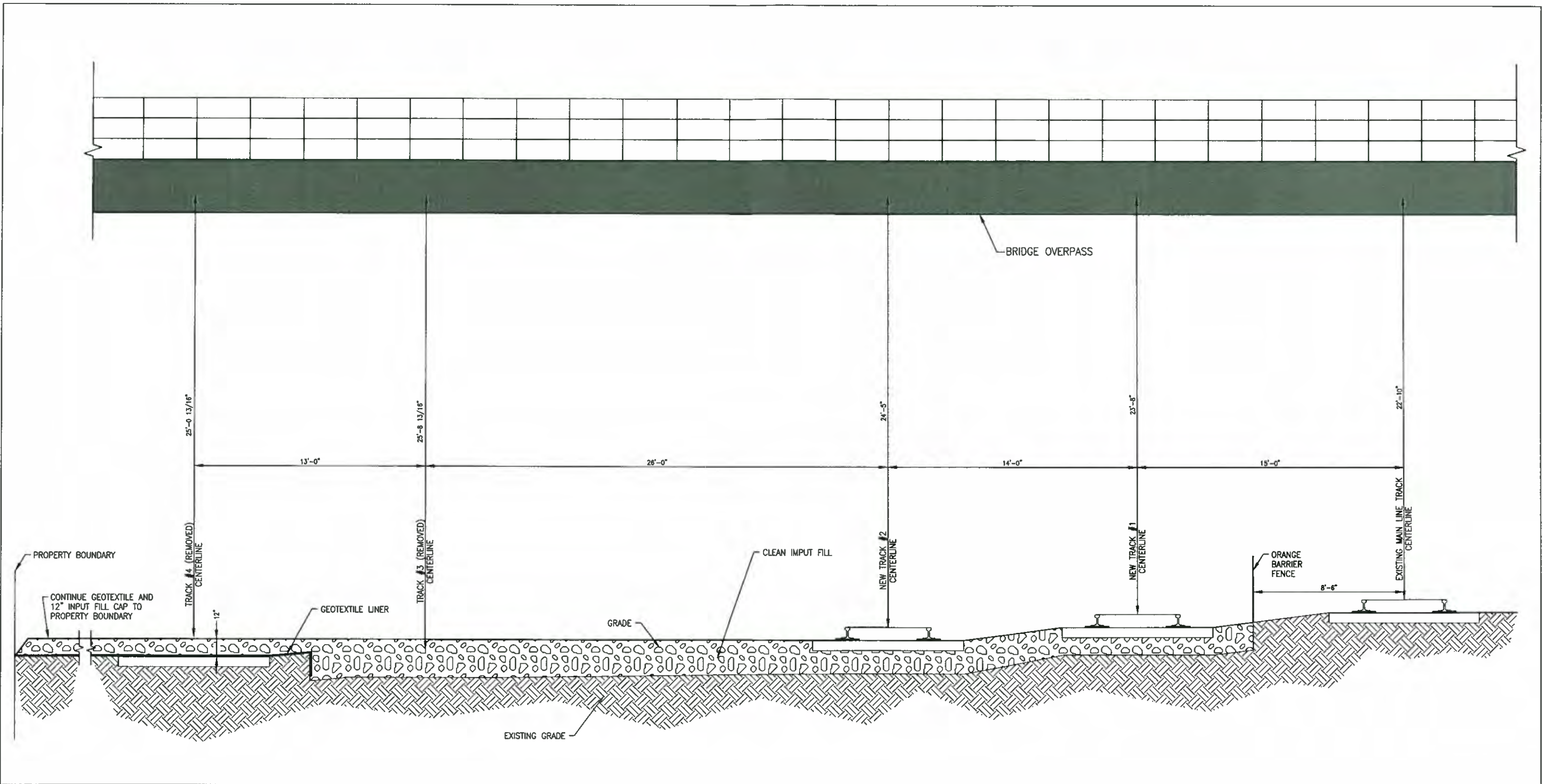
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RAILWAY COMPANY
LIBBY, MONTANA

PHASE 1 & 2
CONTAMINATION REDUCTION ZONE

046022.11/P04SK005

FIGURE 5





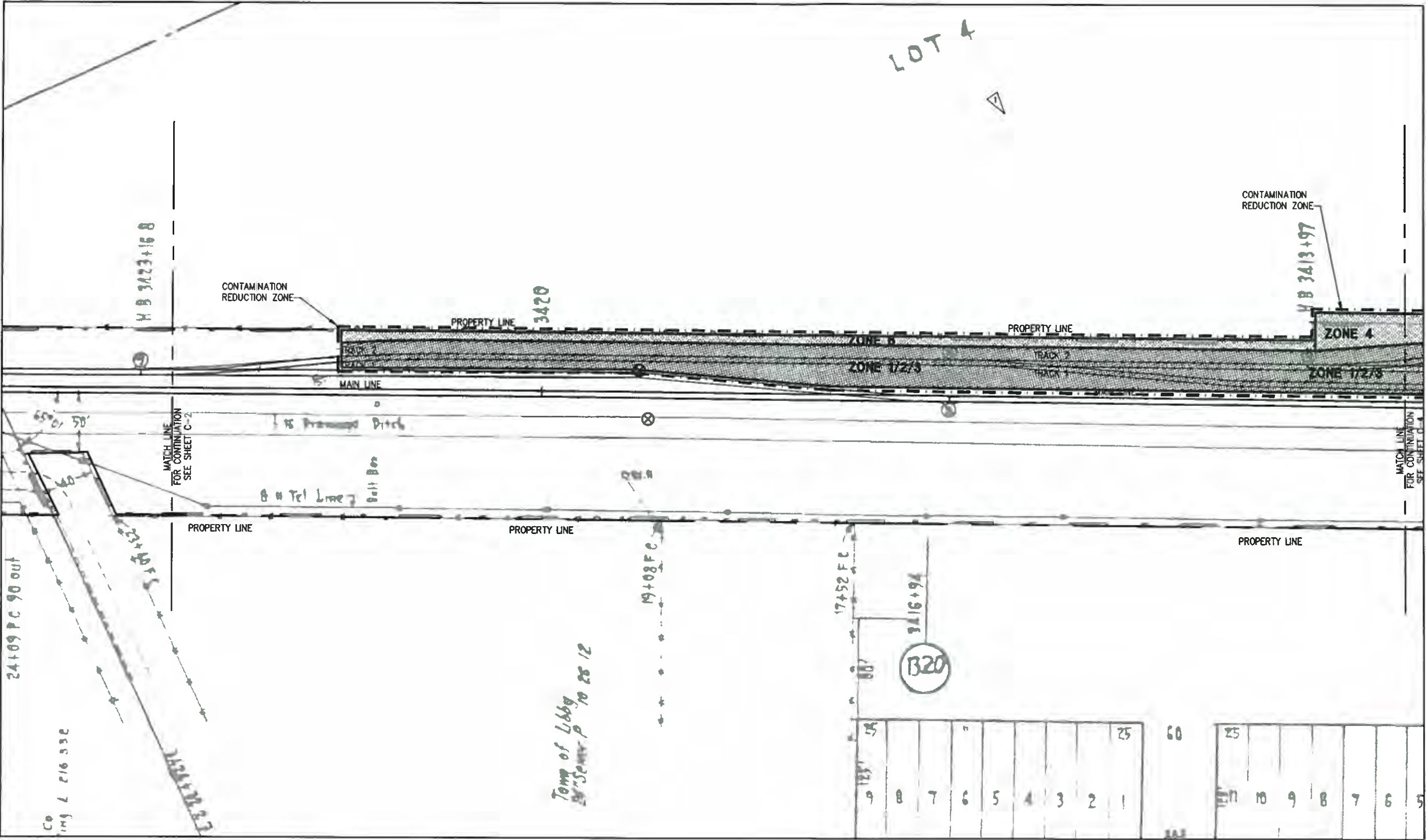
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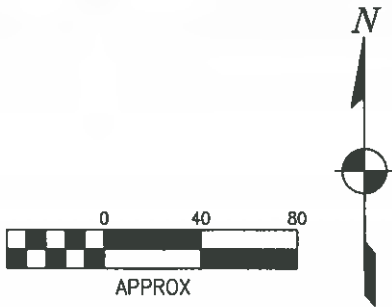
CONCEPTUAL
RECONSTRUCTION SECTION
AT HIGHWAY BRIDGE

046022.11/P04SK006a

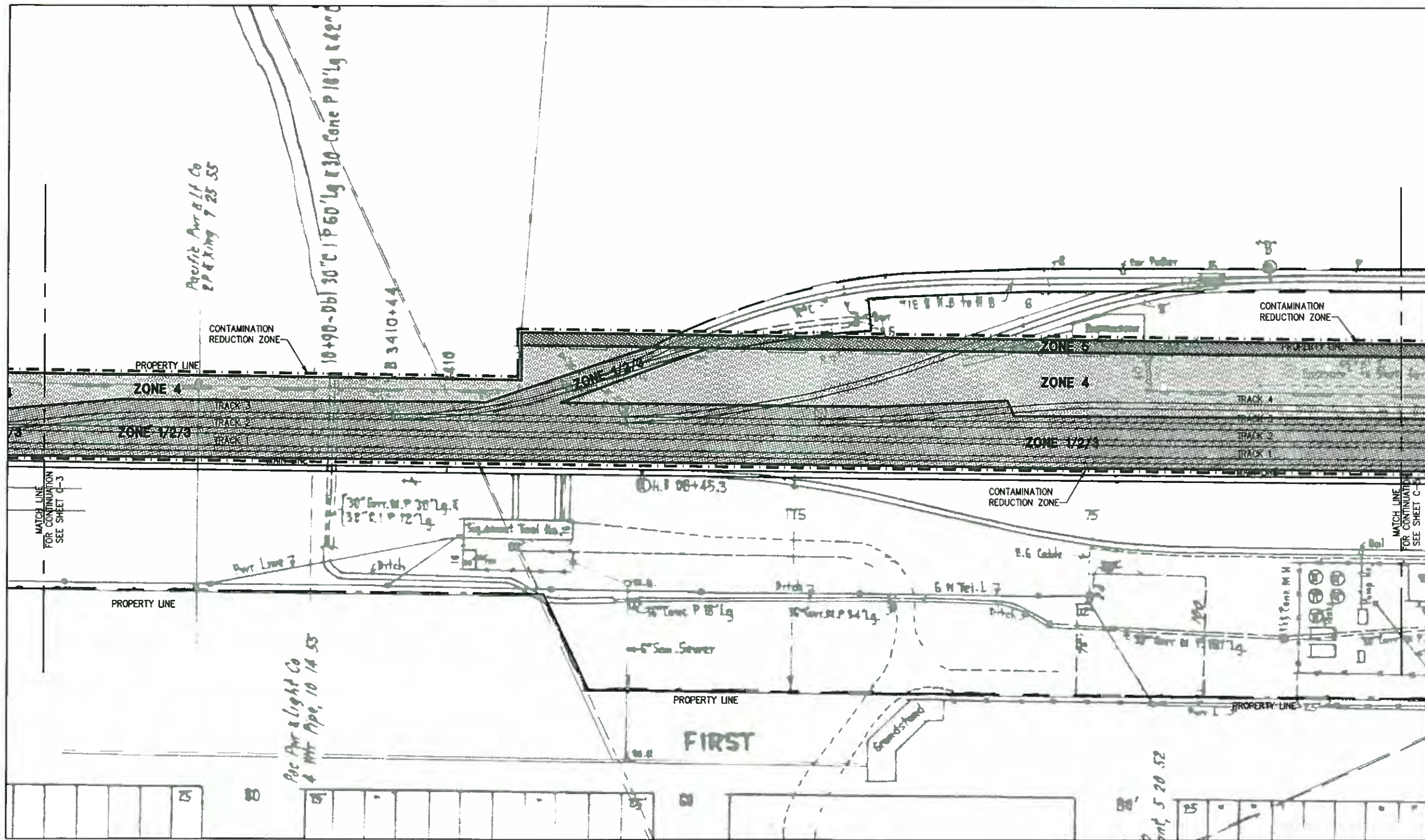
FIGURE 6



- NOTES:
- 1. ZONES 1/2/3 - EXCAVATION AND BACKFILL
 - 2. ZONE 4 - CAP INSTALLATION
 - 3. ZONE 5 - EXCAVATION AND BACKFILL



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**PRELIMINARY LIMITS
OF EXCAVATION, BACKFILL
AND CAP INSTALLATION**



NOTES:

1. ZONES 1/2/3 - EXCAVATION AND BACKFILL
2. ZONE 4 - CAP INSTALLATION
3. ZONE 5 - EXCAVATION AND BACKFILL



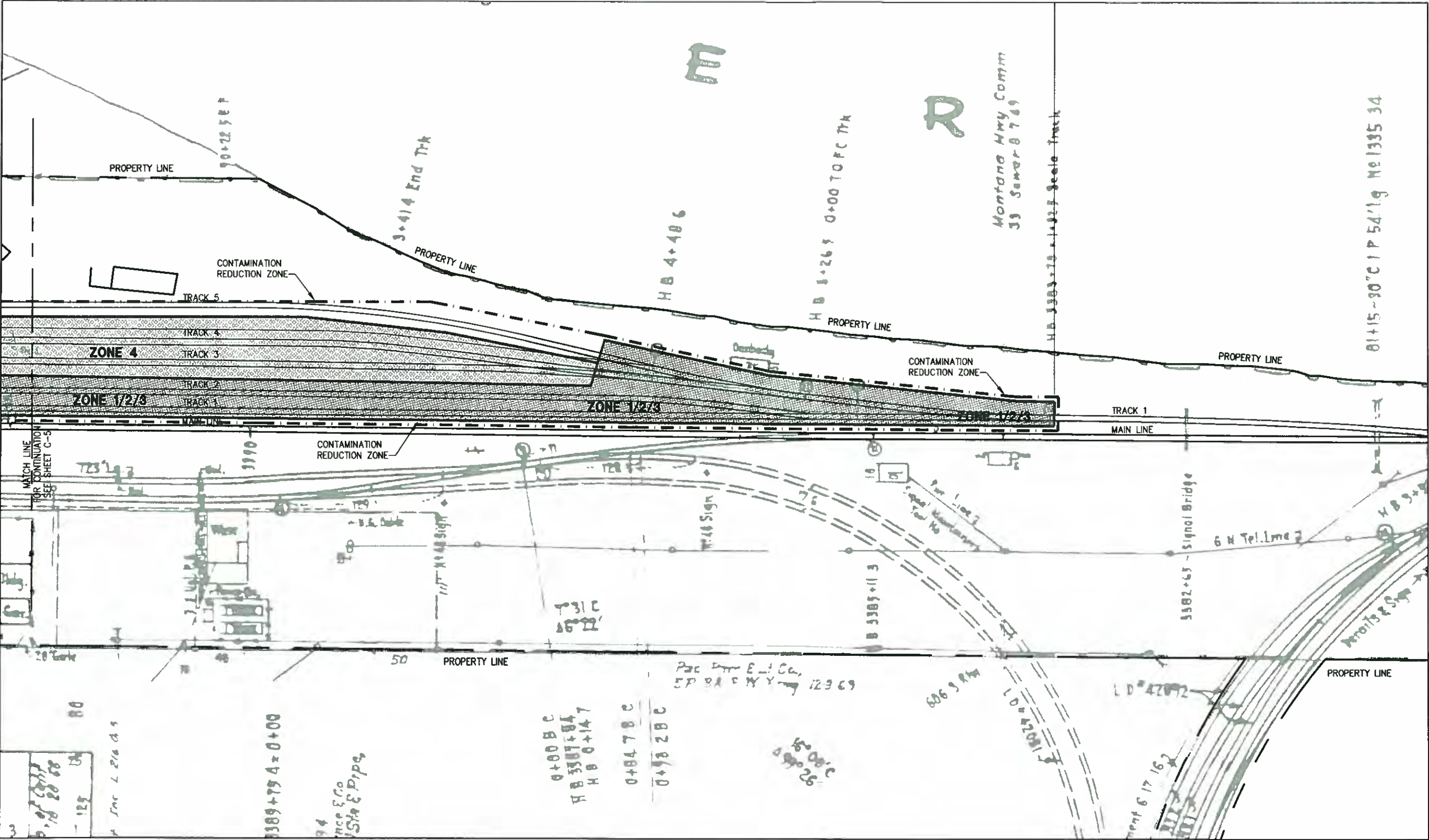
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PRELIMINARY LIMITS
OF EXCAVATION, BACKFILL
AND CAP INSTALLATION

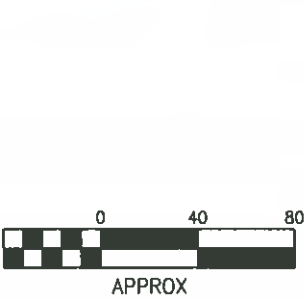
046022.11/P04SK008

FIGURE 8



NOTES:

- 1. ZONES 1/2/3 - EXCAVATION AND BACKFILL
- 2. ZONE 4 - CAP INSTALLATION
- 3. ZONE 5 - EXCAVATION AND BACKFILL



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**PRELIMINARY LIMITS
OF EXCAVATION, BACKFILL
AND CAP INSTALLATION**

046022.11/P04SK010

FIGURE 10

Appendix A

Asbestos and other Fibers by PCM **(NIOSH Method 7400, Issue 2, Revision 3)**

ASBESTOS and OTHER FIBERS by PCM

7400

Various

MW: Various

CAS: Various

RTECS: Various

METHOD: 7400, Issue 2

EVALUATION: FULL

Issue 1: Rev. 3 on 15 May 1989

Issue 2: 15 August 1994

OSHA : 0.1 asbestos fiber (> 5 μ m long)/cc;
1 f/cc/30 min excursion; carcinogen

MSHA: 2 asbestos fibers/cc

NIOSH: 0.1 f/cc (fibers > 5 μ m long)/400 L; carcinogen

ACGIH: 0.2 crocidolite; 0.5 amosite; 2 chrysotile and other
asbestos, fibers/cc; carcinogen

PROPERTIES: solid, fibrous, crystalline, anisotropic

SYNONYMS [CAS #]: actinolite [77536-66-4] or ferroactinolite [15869-07-5]; amosite [12172-73-5]; anthophyllite [77536-67-5]; chrysotile [12001-29-5]; serpentine [18786-24-8]; crocidolite [12001-28-4]; tremolite [77536-68-6]; amphibole asbestos [1332-21-4]; refractory ceramic fibers [142844-00-6]; fibrous glass.

SAMPLING		MEASUREMENT	
SAMPLER:	FILTER (0.45- to 1.2- μ m cellulose ester membrane, 25-mm; conductive cover on cassette)	TECHNIQUE:	LIGHT MICROSCOPY, PHASE CONTRAST
FLOW RATE*:	0.5 to 16 L/min	ANALYTE:	fibers (manual count)
VOL-MIN*:	400 L @ 0.1 fiber/cc	SAMPLE PREPARATION:	acetone - collapse/triacetin - immersion
-MAX*:	(step 4, sampling) *Adjust to give 100 to 1300 fiber/mm ²	COUNTING RULES:	described in previous version of this method as "A" rules [1,3]
SHIPMENT:	routine (pack to reduce shock)	EQUIPMENT:	1. positive phase-contrast microscope 2. Walton-Beckett graticule (100- μ m field of view) Type G-22 3. phase-shift test slide (HSE/NPL)
SAMPLE STABILITY:	stable	CALIBRATION:	HSE/NPL test slide
BLANKS:	2 to 10 field blanks per set	RANGE:	100 to 1300 fibers/mm ² filter area
ACCURACY		ESTIMATED LOD:	7 fibers/mm ² filter area
RANGE STUDIED:	80 to 100 fibers counted	PRECISION (σ_r):	0.10 to 0.12 [1]; see EVALUATION OF METHOD
BIAS:	See EVALUATION OF METHOD		
OVERALL PRECISION (σ_r):	0.115 to 0.13 [1]		
ACCURACY:	See EVALUATION OF METHOD		

APPLICABILITY: The quantitative working range is 0.04 to 0.5 fiber/cc for a 1000-L air sample. The LOD depends on sample volume and quantity of interfering dust, and is <0.01 fiber/cc for atmospheres free of interferences. The method gives an index of airborne fibers. It is primarily used for estimating asbestos concentrations, though PCM does not differentiate between asbestos and other fibers. Use this method in conjunction with electron microscopy (e.g., Method 7402) for assistance in identification of fibers. Fibers < ca. 0.25 μ m diameter will not be detected by this method [4]. This method may be used for other materials such as fibrous glass by using alternate counting rules (see Appendix C).

INTERFERENCES: If the method is used to detect a specific type of fiber, any other airborne fiber may interfere since all particles meeting the counting criteria are counted. Chain-like particles may appear fibrous. High levels of non-fibrous dust particles may obscure fibers in the field of view and increase the detection limit.

OTHER METHODS: This revision replaces Method 7400, Revision #3 (date 5/15/89).

REAGENTS:

1. Acetone,* reagent grade.
2. Triacetin (glycerol triacetate), reagent grade.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: field monitor, 25-mm, three-piece cassette with ca. 50-mm electrically conductive extension cowl and cellulose ester filter, 0.45- to 1.2- μ m pore size, and backup pad.

NOTE 1: Analyze representative filters for fiber background before use to check for clarity and background. Discard the filter lot if mean is ≥ 5 fibers per 100 graticule fields. These are defined as laboratory blanks. Manufacturer-provided quality assurance checks on filter blanks are normally adequate as long as field blanks are analyzed as described below.

NOTE 2: The electrically conductive extension cowl reduces electrostatic effects. Ground the cowl when possible during sampling.

NOTE 3: Use 0.8- μ m pore size filters for personal sampling. The 0.45- μ m filters are recommended for sampling when performing TEM analysis on the same samples. However, their higher pressure drop precludes their use with personal sampling pumps.

NOTE 4: Other cassettes have been proposed that exhibit improved uniformity of fiber deposit on the filter surface, e.g., bellmouthed sampler (Envirometrics, Charleston, SC). These may be used if shown to give measured concentrations equivalent to sampler indicated above for the application.

2. Personal sampling pump, battery or line-powered vacuum, of sufficient capacity to meet flow-rate requirements (see step 4 for flow rate), with flexible connecting tubing.
3. Wire, multi-stranded, 22-gauge; 1", hose clamp to attach wire to cassette.
4. Tape, shrink- or adhesive-
5. Slides, glass, frosted-end, pre-cleaned, 25 x 75-mm.
6. Cover slips, 22- x 22-mm, No. 1-1/2, unless otherwise specified by microscope manufacturer.
7. Lacquer or nail polish.
8. Knife, #10 surgical steel, curved blade.
9. Tweezers.

EQUIPMENT:

10. Acetone flash vaporization system for clearing filters on glass slides (see ref. [5] for specifications or see manufacturer's instructions for equivalent devices).
11. Micropipets or syringes, 5- μ L and 100- to 500- μ L.
12. Microscope, positive phase (dark) contrast, with green or blue filter, adjustable field iris, 8 to 10X eyepiece, and 40 to 45X phase objective (total magnification ca. 400X); numerical aperture = 0.65 to 0.75.
13. Graticule, Walton-Beckett type with 100- μ m diameter circular field (area = 0.00785 mm²) at the specimen plane (Type G-22). Available from Optometrics USA, P.O. Box 699, Ayer, MA 01432 [phone (508)-772-1700], and McCrone Accessories and Components, 850 Pasquinelli Drive, Westmont, IL 60559 [phone (312) 887-7100].
NOTE: The graticule is custom-made for each microscope. (see APPENDIX A for the custom-ordering procedure).
14. HSE/NPL phase contrast test slide, Mark II. Available from Optometrics USA (address above).
15. Telescope, ocular phase-ring centering.
16. Stage micrometer (0.01-mm divisions).

SPECIAL PRECAUTIONS: Acetone is extremely flammable. Take precautions not to ignite it. Heating of acetone in volumes greater than 1 mL must be done in a ventilated laboratory fume hood using a flameless, spark-free heat source.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. To reduce contamination and to hold the cassette tightly together, seal the crease between the cassette base and the cowl with a shrink band or light colored adhesive tape. For personal sampling, fasten the (uncapped) open-face cassette to the worker's lapel. The open face should be oriented downward.
NOTE: The cowl should be electrically grounded during area sampling, especially under conditions of low relative humidity. Use a hose clamp to secure one end of the wire (Equipment, Item 3) to the monitor's cowl. Connect the other end to an earth ground (i.e., cold water pipe).
3. Submit at least two field blanks (or 10% of the total samples, whichever is greater) for each set of samples. Handle field blanks in a manner representative of actual handling of associated samples in the set. Open field blank cassettes at the same time as other cassettes just prior to sampling. Store top covers and cassettes in a clean area (e.g., a closed bag or box) with the top covers from the sampling cassettes during the sampling period.
4. Sample at 0.5 L/min or greater [6]. Adjust sampling flow rate, Q (L/min), and time, t (min), to produce a fiber density, E, of 100 to 1300 fibers/mm² ($3.85 \cdot 10^4$ to $5 \cdot 10^5$ fibers per 25-mm filter with effective collection area $A_c = 385$ mm²) for optimum accuracy. These variables are related to the action level (one-half the current standard), L (fibers/cc), of the fibrous aerosol being sampled by:

$$t = \frac{A_c \cdot E}{Q \cdot L \cdot 10^3}, \text{ min.}$$

NOTE 1: The purpose of adjusting sampling times is to obtain optimum fiber loading on the filter. The collection efficiency does not appear to be a function of flow rate in the range of 0.5 to 16 L/min for asbestos fibers [7]. Relatively large diameter fibers (>3 µm) may exhibit significant aspiration loss and inlet deposition. A sampling rate of 1 to 4 L/min for 8 h is appropriate in atmospheres containing ca. 0.1 fiber/cc in the absence of significant amounts of non-asbestos dust. Dusty atmospheres require smaller sample volumes (≤400 L) to obtain countable samples. In such cases take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high flow rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres, where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3000 to 10000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust. If ≥ 50% of the filter surface is covered with particles, the filter may be too overloaded to count and will bias the measured fiber concentration.

NOTE 2: OSHA regulations specify a minimum sampling volume of 48 L for an excursion measurement, and a maximum sampling rate of 2.5 L/min [3].

5. At the end of sampling, replace top cover and end plugs.
6. Ship samples with conductive cowl attached in a rigid container with packing material to prevent jostling or damage.

NOTE: Do not use untreated polystyrene foam in shipping container because electrostatic forces may cause fiber loss from sample filter.

SAMPLE PREPARATION:

NOTE 1: The object is to produce samples with a smooth (non-grainy) background in a medium with refractive index ≤1.46. This method collapses the filter for easier focusing and produces permanent (1 - 10 years) mounts which are useful for quality control and interlaboratory comparison. The aluminum "hot block" or similar flash vaporization techniques may be used outside the laboratory [2]. Other mounting techniques meeting the above criteria may also be used (e.g., the laboratory fume hood procedure for generating acetone vapor as described in Method 7400 - revision of 5/15/85, or the non-permanent field mounting technique used in P&CAM 239 [3,7,8,9]). Unless the effective filtration area is known, determine the area and record the information referenced against the sample ID number [1,9,10,11].

NOTE 2: Excessive water in the acetone may slow the clearing of the filter, causing material to be washed off the surface of the filter. Also, filters that have been exposed to high humidities prior to clearing may have a grainy background.

7. Ensure that the glass slides and cover slips are free of dust and fibers.
8. Adjust the rheostat to heat the "hot block" to ca. 70 °C [2].
NOTE: If the "hot block" is not used in a fume hood, it must rest on a ceramic plate and be isolated from any surface susceptible to heat damage.
9. Mount a wedge cut from the sample filter on a clean glass slide.
 - a. Cut wedges of ca. 25% of the filter area with a curved-blade surgical steel knife using a rocking motion to prevent tearing. Place wedge, dust side up, on slide.
NOTE: Static electricity will usually keep the wedge on the slide.

- b. Insert slide with wedge into the receiving slot at base of "hot block". Immediately place tip of a micropipet containing ca. 250 μ L acetone (use the minimum volume needed to consistently clear the filter sections) into the inlet port of the PTFE cap on top of the "hot block" and inject the acetone into the vaporization chamber with a slow, steady pressure on the plunger button while holding pipet firmly in place. After waiting 3 to 5 sec for the filter to clear, remove pipet and slide from their ports.
CAUTION: Although the volume of acetone used is small, use safety precautions. Work in a well-ventilated area (e.g., laboratory fume hood). Take care not to ignite the acetone. Continuous use of this device in an unventilated space may produce explosive acetone vapor concentrations.
- c. Using the 5- μ L micropipet, immediately place 3.0 to 3.5 μ L triacetin on the wedge. Gently lower a clean cover slip onto the wedge at a slight angle to reduce bubble formation. Avoid excess pressure and movement of the cover glass.
NOTE: If too many bubbles form or the amount of triacetin is insufficient, the cover slip may become detached within a few hours. If excessive triacetin remains at the edge of the filter under the cover slip, fiber migration may occur.
- d. Mark the outline of the filter segment with a glass marking pen to aid in microscopic evaluation.
- e. Glue the edges of the cover slip to the slide using lacquer or nail polish [12]. Counting may proceed immediately after clearing and mounting are completed.
NOTE: If clearing is slow, warm the slide on a hotplate (surface temperature 50 °C) for up to 15 min to hasten clearing. Heat carefully to prevent gas bubble formation.

CALIBRATION AND QUALITY CONTROL:

10. Microscope adjustments. Follow the manufacturers instructions. At least once daily use the telescope ocular (or Bertrand lens, for some microscopes) supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric. With each microscope, keep a logbook in which to record the dates of microscope cleanings and major servicing.
 - a. Each time a sample is examined, do the following:
 - (1) Adjust the light source for even illumination across the field of view at the condenser iris. Use Kohler illumination, if available. With some microscopes, the illumination may have to be set up with bright field optics rather than phase contract optics.
 - (2) Focus on the particulate material to be examined.
 - (3) Make sure that the field iris is in focus, centered on the sample, and open only enough to fully illuminate the field of view.
 - b. Check the phase-shift detection limit of the microscope periodically for each analyst/microscope combination:
 - (1) Center the HSE/NPL phase-contrast test slide under the phase objective.
 - (2) Bring the blocks of grooved lines into focus in the graticule area.
NOTE: The slide contains seven blocks of grooves (ca. 20 grooves per block) in descending order of visibility. For asbestos counting the microscope optics must completely resolve the grooved lines in block 3 although they may appear somewhat faint, and the grooved lines in blocks 6 and 7 must be invisible when centered in the graticule area. Blocks 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope which fails to meet these requirements has resolution either too low or too high for fiber counting.
 - (3) If image quality deteriorates, clean the microscope optics. If the problem persists, consult the microscope manufacturer.
11. Document the laboratory's precision for each counter for replicate fiber counts.
 - a. Maintain as part of the laboratory quality assurance program a set of reference slides to be used on a daily basis [13]. These slides should consist of filter preparations including a range of loadings and background dust levels from a variety of sources including both field and reference samples (e.g., PAT, AAR, commercial samples). The Quality Assurance Officer

should maintain custody of the reference slides and should supply each counter with a minimum of one reference slide per workday. Change the labels on the reference slides periodically so that the counter does not become familiar with the samples.

- b. From blind repeat counts on reference slides, estimate the laboratory intra- and intercounter precision. Obtain separate values of relative standard deviation (S_r) for each sample matrix analyzed in each of the following ranges: 5 to 20 fibers in 100 graticule fields, >20 to 50 fibers in 100 graticule fields, and >50 to 100 fibers in 100 graticule fields. Maintain control charts for each of these data files.

NOTE: Certain sample matrices (e.g., asbestos cement) have been shown to give poor precision [9].

12. Prepare and count field blanks along with the field samples. Report counts on each field blank.
NOTE 1: The identity of blank filters should be unknown to the counter until all counts have been completed.
NOTE 2: If a field blank yields greater than 7 fibers per 100 graticule fields, report possible contamination of the samples.
13. Perform blind recounts by the same counter on 10% of filters counted (slides relabeled by a person other than the counter). Use the following test to determine whether a pair of counts by the same counter on the same filter should be rejected because of possible bias: Discard the sample if the absolute value of the difference between the square roots of the two counts (in fiber/mm²) exceeds $2.77 (X)S_r$, where X = average of the square roots of the two fiber counts

(in fiber/mm²) and $S_r = \frac{S_r}{2}$, where S_r is the intracounter relative standard deviation for the

appropriate count range (in fibers) determined in step 11. For more complete discussions see reference [13].

NOTE 1: Since fiber counting is the measurement of randomly placed fibers which may be described by a Poisson distribution, a square root transformation of the fiber count data will result in approximately normally distributed data [13].

NOTE 2: If a pair of counts is rejected by this test, recount the remaining samples in the set and test the new counts against the first counts. Discard all rejected paired counts. It is not necessary to use this statistic on blank counts.

14. The analyst is a critical part of this analytical procedure. Care must be taken to provide a non-stressful and comfortable environment for fiber counting. An ergonomically designed chair should be used, with the microscope eyepiece situated at a comfortable height for viewing. External lighting should be set at a level similar to the illumination level in the microscope to reduce eye fatigue. In addition, counters should take 10-to-20 minute breaks from the microscope every one or two hours to limit fatigue [14]. During these breaks, both eye and upper back/neck exercises should be performed to relieve strain.
15. All laboratories engaged in asbestos counting should participate in a proficiency testing program such as the AIHA-NIOSH Proficiency Analytical Testing (PAT) Program for asbestos and routinely exchange field samples with other laboratories to compare performance of counters.

MEASUREMENT:

16. Center the slide on the stage of the calibrated microscope under the objective lens. Focus the microscope on the plane of the filter.
17. Adjust the microscope (Step 10).
NOTE: Calibration with the HSE/NPL test slide determines the minimum detectable fiber diameter (ca. 0.25 μ m) [4].
18. Counting rules: (same as P&CAM 239 rules [1,10,11]; see examples in APPENDIX B).
 - a. Count any fiber longer than 5 μ m which lies entirely within the graticule area.
 - (1) Count only fibers longer than 5 μ m. Measure length of curved fibers along the curve.
 - (2) Count only fibers with a length-to-width ratio equal to or greater than 3:1.
 - b. For fibers which cross the boundary of the graticule field:
 - (1) Count as 1/2 fiber any fiber with only one end lying within the graticule area, provided that the fiber meets the criteria of rule a above.

- (2) Do not count any fiber which crosses the graticule boundary more than once.
 - (3) Reject and do not count all other fibers.
 - c. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of a fiber.
 - d. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields. Stop at 100 graticule fields regardless of count.
19. Start counting from the tip of the filter wedge and progress along a radial line to the outer edge. Shift up or down on the filter, and continue in the reverse direction. Select graticule fields randomly by looking away from the eyepiece briefly while advancing the mechanical stage. Ensure that, as a minimum, each analysis covers one radial line from the filter center to the outer edge of the filter. When an agglomerate or bubble covers ca. 1/6 or more of the graticule field, reject the graticule field and select another. Do not report rejected graticule fields in the total number counted.
- NOTE 1: When counting a graticule field, continuously scan a range of focal planes by moving the fine focus knob to detect very fine fibers which have become embedded in the filter. The small-diameter fibers will be very faint but are an important contribution to the total count. A minimum counting time of 15 seconds per field is appropriate for accurate counting.
- NOTE 2: This method does not allow for differentiation of fibers based on morphology. Although some experienced counters are capable of selectively counting only fibers which appear to be asbestiform, there is presently no accepted method for ensuring uniformity of judgment between laboratories. It is, therefore, incumbent upon all laboratories using this method to report total fiber counts. If serious contamination from non-asbestos fibers occurs in samples, other techniques such as transmission electron microscopy must be used to identify the asbestos fiber fraction present in the sample (see NIOSH Method 7402). In some cases (i.e., for fibers with diameters $>1 \mu\text{m}$), polarized light microscopy (as in NIOSH Method 7403) may be used to identify and eliminate interfering non-crystalline fibers [15].
- NOTE 3: Do not count at edges where filter was cut. Move in at least 1 mm from the edge.
- NOTE 4: Under certain conditions, electrostatic charge may affect the sampling of fibers. These electrostatic effects are most likely to occur when the relative humidity is low (below 20%), and when sampling is performed near the source of aerosol. The result is that deposition of fibers on the filter is reduced, especially near the edge of the filter. If such a pattern is noted during fiber counting, choose fields as close to the center of the filter as possible [5].
- NOTE 5: Counts are to be recorded on a data sheet that provides, as a minimum, spaces on which to record the counts for each field, filter identification number, analyst's name, date, total fibers counted, total fields counted, average count, fiber density, and commentary. Average count is calculated by dividing the total fiber count by the number of fields observed. Fiber density (fibers/mm²) is defined as the average count (fibers/field) divided by the field (graticule) area (mm²/field).

CALCULATIONS AND REPORTING OF RESULTS

20. Calculate and report fiber density on the filter, E (fibers/mm²), by dividing the average fiber count per graticule field, F/n_f , minus the mean field blank count per graticule field, B/n_b , by the graticule field area, A_f (approx. 0.00785 mm²):

$$E = \frac{\left(\frac{F}{n_f} - \frac{B}{n_b} \right)}{A_f}, \text{ fibers/mm}^2.$$

NOTE: Fiber counts above 1300 fibers/mm² and fiber counts from samples with >50% of filter area covered with particulate should be reported as "uncountable" or "probably biased." Other fiber counts outside the 100-1300 fiber/mm² range should be reported as having "greater than optimal variability" and as being "probably biased."

21. Calculate and report the concentration, C (fibers/cc), of fibers in the air volume sampled, V (L), using the effective collection area of the filter, A_c (approx. 385 mm² for a 25-mm filter):

$$C = \frac{(E)(A_c)}{V \cdot 10^3}$$

NOTE: Periodically check and adjust the value of A_c, if necessary.

22. Report intralaboratory and interlaboratory relative standard deviations (from Step 11) with each set of results.

NOTE: Precision depends on the total number of fibers counted [1,16]. Relative standard deviation is documented in references [1,15-17] for fiber counts up to 100 fibers in 100 graticule fields. Comparability of interlaboratory results is discussed below. As a first approximation, use 213% above and 49% below the count as the upper and lower confidence limits for fiber counts greater than 20 (Fig. 1).

EVALUATION OF METHOD:

- A. This method is a revision of P&CAM 239 [10]. A summary of the revisions is as follows:

1. Sampling:

The change from a 37-mm to a 25-mm filter improves sensitivity for similar air volumes. The change in flow rates allows for 2-m³ full-shift samples to be taken, providing that the filter is not overloaded with non-fibrous particulates. The collection efficiency of the sampler is not a function of flow rate in the range 0.5 to 16 L/min [10].

2. Sample Preparation Technique:

The acetone vapor-triacetin preparation technique is a faster, more permanent mounting technique than the dimethyl phthalate/diethyl oxalate method of P&CAM 239 [2,4,10]. The aluminum "hot block" technique minimizes the amount of acetone needed to prepare each sample.

3. Measurement:

- a. The Walton-Beckett graticule standardizes the area observed [14,18,19].
- b. The HSE/NPL test slide standardizes microscope optics for sensitivity to fiber diameter [4,14].
- c. Because of past inaccuracies associated with low fiber counts, the minimum recommended loading has been increased to 100 fibers/mm² filter area (a total of 78.5 fibers counted in 100 fields, each with field area = .00785 mm².) Lower levels generally result in an overestimate of the fiber count when compared to results in the recommended analytical range [20]. The recommended loadings should yield intracounter S_r in the range of 0.10 to 0.17 [21,22,23].

- B. Interlaboratory comparability:

An international collaborative study involved 16 laboratories using prepared slides from the asbestos cement, milling, mining, textile, and friction material industries [9]. The relative standard deviations (S_r) varied with sample type and laboratory. The ranges were:

	<u>Intralaboratory S_r</u>	<u>Interlaboratory S_r</u>	<u>Overall S_r</u>
AIA (NIOSH A Rules)*	0.12 to 0.40	0.27 to 0.85	0.46
Modified CRS (NIOSH B Rules)**	0.11 to 0.29	0.20 to 0.35	0.25

* Under AIA rules, only fibers having a diameter less than 3 μ m are counted and fibers attached to particles larger than 3 μ m are not counted. NIOSH A Rules are otherwise similar to the AIA rules.

** See Appendix C.

A NIOSH study conducted using field samples of asbestos gave intralaboratory S_r in the range 0.17 to 0.25 and an interlaboratory S_r of 0.45 [21]. This agrees well with other recent studies [9,14,16].

At this time, there is no independent means for assessing the overall accuracy of this method. One measure of reliability is to estimate how well the count for a single sample agrees with the mean count from a large number of laboratories. The following discussion indicates how this estimation can be carried out based on measurements of the interlaboratory variability, as well as showing how the results of this method relate to the theoretically attainable counting precision and to measured intra- and interlaboratory S_r. (NOTE: The following discussion does not include bias estimates and should not be taken to indicate that lightly loaded samples are as accurate as properly loaded ones).

Theoretically, the process of counting randomly (Poisson) distributed fibers on a filter surface will give an S_r that depends on the number, N, of fibers counted:

$$S_r = 1/(N)^{1/2} \quad (1)$$

Thus S_r is 0.1 for 100 fibers and 0.32 for 10 fibers counted. The actual S_r found in a number of studies is greater than these theoretical numbers [17,19,20,21].

An additional component of variability comes primarily from subjective interlaboratory differences. In a study of ten counters in a continuing sample exchange program, Ogden [15] found this subjective component of intralaboratory S_r to be approximately 0.2 and estimated the overall S_r by the term:

$$\frac{[N + (0.2 \cdot N)^2]^{1/2}}{N} \quad (2)$$

Ogden found that the 90% confidence interval of the individual intralaboratory counts in relation to the means were +2 S_r and - 1.5 S_r. In this program, one sample out of ten was a quality control sample. For laboratories not engaged in an intensive quality assurance program, the subjective component of variability can be higher.

In a study of field sample results in 46 laboratories, the Asbestos Information Association also found that the variability had both a constant component and one that depended on the fiber count [14]. These results gave a subjective interlaboratory component of S_r (on the same basis as Ogden's) for field samples of ca. 0.45. A similar value was obtained for 12 laboratories analyzing a set of 24 field samples [21]. This value falls slightly above the range of S_r (0.25 to 0.42 for 1984-85) found for 80 reference laboratories in the NIOSH PAT program for laboratory-generated samples [17].

A number of factors influence S_r for a given laboratory, such as that laboratory's actual counting performance and the type of samples being analyzed. In the absence of other information, such as from an interlaboratory quality assurance program using field samples, the value for the subjective component of variability is chosen as 0.45. It is hoped that the laboratories will carry out the recommended interlaboratory quality assurance programs to improve their performance and thus reduce the S_r.

The above relative standard deviations apply when the population mean has been determined. It is more useful, however, for laboratories to estimate the 90% confidence interval on the mean count from a single sample fiber count (Figure 1). These curves assume similar shapes of the count distribution for interlaboratory and intralaboratory results [16].

For example, if a sample yields a count of 24 fibers, Figure 1 indicates that the mean interlaboratory count will fall within the range of 227% above and 52% below that value 90% of the time. We can apply these percentages directly to the air concentrations as well. If, for instance, this sample (24 fibers counted) represented a 500-L volume, then the measured concentration is 0.02 fibers/mL (assuming 100 fields counted, 25-mm filter, 0.00785 mm² counting field area). If this same sample were counted by a group of laboratories, there is a 90% probability that the mean would fall between 0.01 and 0.08 fiber/mL. These limits should be reported in any comparison of results between laboratories.

Note that the S_r of 0.45 used to derive Figure 1 is used as an estimate for a random group of laboratories. If several laboratories belonging to a quality assurance group can show that their interlaboratory S_r is smaller, then it is more correct to use that smaller S_r . However, the estimated S_r of 0.45 is to be used in the absence of such information. Note also that it has been found that S_r can be higher for certain types of samples, such as asbestos cement [9].

Quite often the estimated airborne concentration from an asbestos analysis is used to compare to a regulatory standard. For instance, if one is trying to show compliance with an 0.5 fiber/mL standard using a single sample on which 100 fibers have been counted, then Figure 1 indicates that the 0.5 fiber/mL standard must be 213% higher than the measured air concentration. This indicates that if one measures a fiber concentration of 0.16 fiber/mL (100 fibers counted), then the mean fiber count by a group of laboratories (of which the compliance laboratory might be one) has a 95% chance of being less than 0.5 fibers/mL; i.e., $0.16 + 2.13 \times 0.16 = 0.5$.

It can be seen from Figure 1 that the Poisson component of the variability is not very important unless the number of fibers counted is small. Therefore, a further approximation is to simply use +213% and -49% as the upper and lower confidence values of the mean for a 100-fiber count.

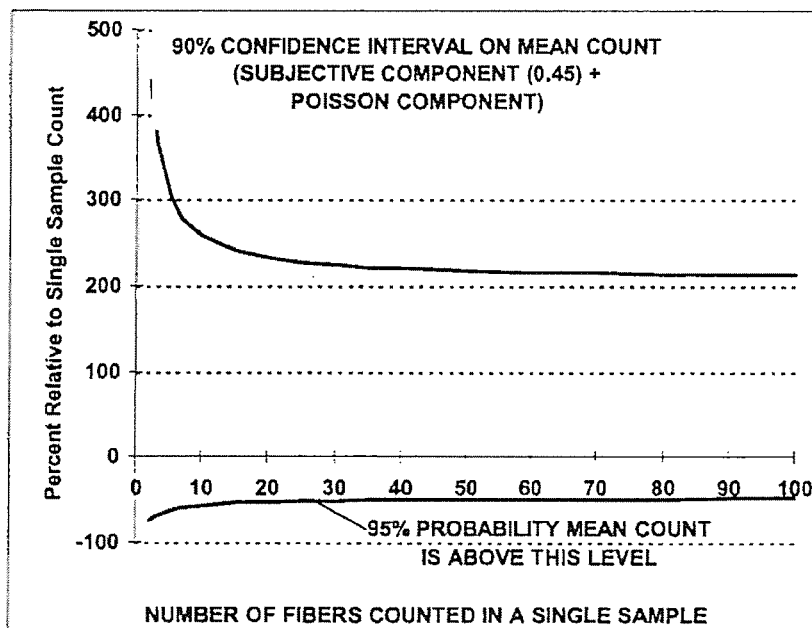


Figure 1. Interlaboratory Precision of Fiber Counts

The curves in Figures 1 are defined by the following equations:

$$\text{UCL} = \frac{2X + 2.25 + [(2.25 + 2X)^2 - 4(1 - 2.25S_r^2)X^2]^{1/2}}{2(1 - 2.25S_r^2)} \quad (3)$$

$$\text{LCL} = \frac{2X + 4 - [(4 + 2X)^2 - 4(1 - 4S_r^2)X^2]^{1/2}}{2(1 - 4S_r^2)} \quad (4)$$

where S_r = subjective interlaboratory relative standard deviation, which is close to the total interlaboratory S_r when approximately 100 fibers are counted.

X = total fibers counted on sample

LCL = lower 95% confidence limit.

UCL = upper 95% confidence limit.

Note that the range between these two limits represents 90% of the total range.

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APPENDIX A: CALIBRATION OF THE WALTON-BECKETT GRATICULE:

Before ordering the Walton-Beckett graticule, the following calibration must be done to obtain a counting area (D) 100 μ m in diameter at the image plane. The diameter, d_c (mm), of the circular counting area and the disc diameter must be specified when ordering the graticule.

1. Insert any available graticule into the eyepiece and focus so that the graticule lines are sharp and clear.
2. Set the appropriate interpupillary distance and, if applicable, reset the binocular head adjustment so that the magnification remains constant.
3. Install the 40 to 45X phase objective.
4. Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.
5. Measure the magnified grid length of the graticule, L_g (μ m), using the stage micrometer.
6. Remove the graticule from the microscope and measure its actual grid length, L_a (mm). This can best be accomplished by using a stage fitted with verniers.
7. Calculate the circle diameter, d_c (mm), for the Walton-Beckett graticule:

$$d_c = \frac{L_a}{L_o} \times D. \quad (5)$$

Example: If $L_o = 112 \mu\text{m}$, $L_a = 4.5 \text{ mm}$ and $D = 100 \mu\text{m}$, then $d_c = 4.02 \text{ mm}$.

8. Check the field diameter, D (acceptable range $100 \mu\text{m} \pm 2 \mu\text{m}$) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine field area (acceptable range 0.00754 mm^2 to 0.00817 mm^2).

APPENDIX B: COMPARISON OF COUNTING RULES:

Figure 2 shows a Walton-Beckett graticule as seen through the microscope. The rules will be discussed as they apply to the labeled objects in the figure.

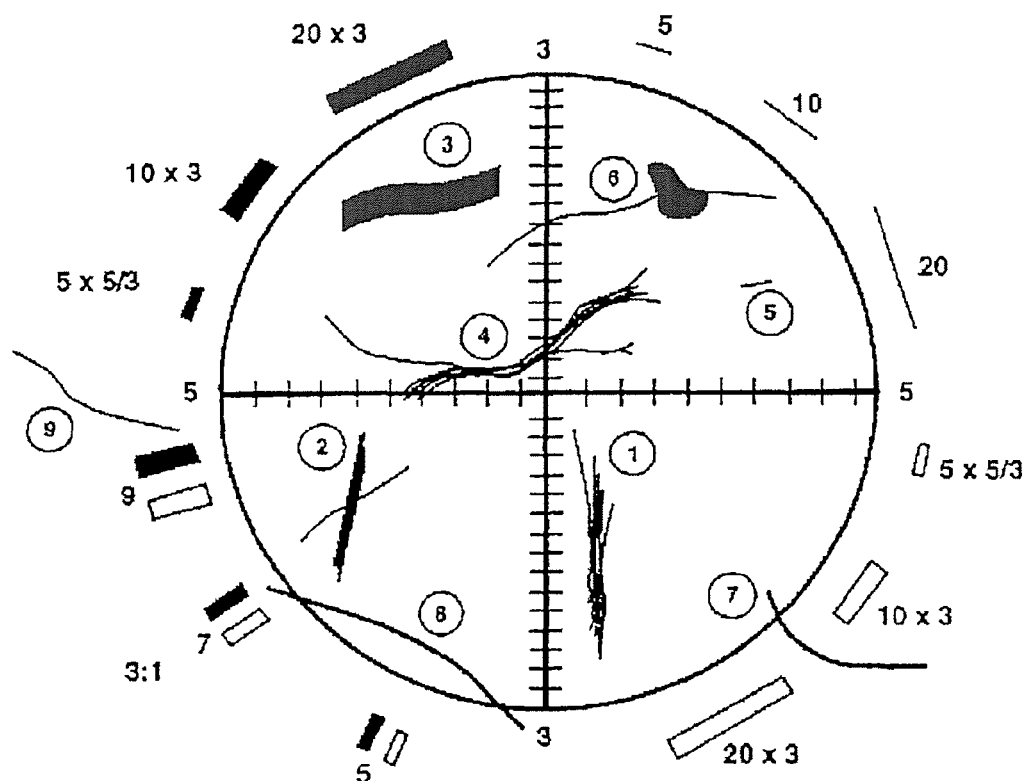


Figure 2. Walton-Beckett graticule with fibers.

These rules are sometimes referred to as the "A" rules.

FIBER COUNT

<u>Object</u>	<u>Count</u>	<u>DISCUSSION</u>
1	1 fiber	Optically observable asbestos fibers are actually bundles of fine fibrils. If the fibrils seem to be from the same bundle the object is counted as a single fiber. Note, however, that all objects meeting length and aspect ratio criteria are counted whether or not they appear to be asbestos.
2	2 fiber	If fibers meeting the length and aspect ratio criteria (length $>5 \mu\text{m}$ and length-to-width ratio >3 to 1) overlap, but do not seem to be part of the same bundle, they are counted as separate fibers.
3	1 fiber	Although the object has a relatively large diameter ($>3 \mu\text{m}$), it is counted as fiber under the rules. There is no upper limit on the fiber diameter in the counting rules. Note that fiber width is measured at the widest compact section of the object.
4	1 fiber	Although long fine fibrils may extend from the body of a fiber, these fibrils are considered part of the fiber if they seem to have originally been part of the bundle.
5	Do not count	If the object is $\leq 5 \mu\text{m}$ long, it is not counted.
6	1 fiber	A fiber partially obscured by a particle is counted as one fiber. If the fiber ends emanating from a particle do not seem to be from the same fiber and each end meets the length and aspect ratio criteria, they are counted as separate fibers.
7	1/2 fiber	A fiber which crosses into the graticule area one time is counted as 1/2 fiber.
8	Do not count	Ignore fibers that cross the graticulate boundary more than once.
9	Do not count	Ignore fibers that lie outside the graticule boundary.

APPENDIX C. ALTERNATE COUNTING RULES FOR NON-ASBESTOS FIBERS

Other counting rules may be more appropriate for measurement of specific non-asbestos fiber types, such as fibrous glass. These include the "B" rules given below (from NIOSH Method 7400, Revision #2, dated 8/15/87), the World Health Organization reference method for man-made mineral fiber [24], and the NIOSH fibrous glass criteria document method [25]. The upper diameter limit in these methods prevents measurements of non-thoracic fibers. It is important to note that the aspect ratio limits included in these methods vary. NIOSH recommends the use of the 3:1 aspect ratio in counting fibers.

It is emphasized that hybridization of different sets of counting rules is not permitted. Report specifically which set of counting rules are used with the analytical results.

"B" COUNTING RULES:

1. Count only ends of fibers. Each fiber must be longer than 5 μ m and less than 3 μ m diameter.
2. Count only ends of fibers with a length-to-width ratio equal to or greater than 5:1.
3. Count each fiber end which falls within the graticule area as one end, provided that the fiber meets rules 1 and 2 above. Add split ends to the count as appropriate if the split fiber segment also meets the criteria of rules 1 and 2 above.
4. Count visibly free ends which meet rules 1 and 2 above when the fiber appears to be attached to another particle, regardless of the size of the other particle. Count the end of a fiber obscured by another particle if the particle covering the fiber end is less than 3 μ m in diameter.
5. Count free ends of fibers emanating from large clumps and bundles up to a maximum of 10 ends (5 fibers), provided that each segment meets rules 1 and 2 above.
6. Count enough graticule fields to yield 200 ends. Count a minimum of 20 graticule fields. Stop at 100 graticule fields, regardless of count.
7. Divide total end count by 2 to yield fiber count.

APPENDIX D. EQUIVALENT LIMITS OF DETECTION AND QUANTITATION

<u>fiber density on filter*</u>		<u>fiber concentration in air, f/cc</u>	
<u>fibers</u>		<u>400-L air</u>	<u>1000-L air</u>
<u>per 100 fields</u>	<u>fibers/mm²</u>	<u>sample</u>	<u>sample</u>
200	255	0.25	0.10
100	127	0.125	0.05
LOQ 80	102	0.10	0.04
50	64	0.0625	0.025
25	32	0.03	0.0125
20	25	0.025	0.010
10	12.7	0.0125	0.005
8	10.2	0.010	0.004
LOD 5.5	7	0.00675	0.0027

* Assumes 385 mm² effective filter collection area, and field area = 0.00785 mm², for relatively "clean" (little particulate aside from fibers) filters.

Appendix B

AHERA TEM Method
(Appendix A to 40 CFR, Chapter 1,
Part 763, Subpart E)

Electronic Code of Federal Regulations



THIS DATA CURRENT AS OF THE FEDERAL REGISTER DATED NOVEMBER 6, 2002

40 CFR - CHAPTER I - PART 763

[View Part](#)**Appendix A to Subpart E of Part 763 -- Interim Transmission Electron Microscopy Analytical Methods -- Mandatory and Nonmandatory -- and Mandatory Section to Determine Completion of Response Actions****I. Introduction**

The following appendix contains three units. The first unit is the mandatory transmission electron microscopy (TEM) method which all laboratories must follow; it is the minimum requirement for analysis of air samples for asbestos by TEM. The mandatory method contains the essential elements of the TEM method. The second unit contains the complete non-mandatory method. The non-mandatory method supplements the mandatory method by including additional steps to improve the analysis. EPA recommends that the non-mandatory method be employed for analyzing air filters; however, the laboratory may choose to employ the mandatory method. The non-mandatory method contains the same minimum requirements as are outlined in the mandatory method. Hence, laboratories may choose either of the two methods for analyzing air samples by TEM.

The final unit of this Appendix A to subpart E defines the steps which must be taken to determine completion of response actions. This unit is mandatory.

II. Mandatory Transmission Electron Microscopy Method**A. Definitions of Terms**

1. *Analytical sensitivity* -- Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 structures/cm³.
2. *Asbestiform* -- A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.
3. *Aspect ratio* -- A ratio of the length to the width of a particle. Minimum aspect ratio as defined by

this method is equal to or greater than 5:1.

4. *Bundle* -- A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area* -- A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a maximum of 53 structures/mm² for any single preparation for that same area.

6. *Cluster* -- A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED* -- Electron diffraction.

8. *EDXA* -- Energy dispersive X-ray analysis.

9. *Fiber* -- A structure greater than or equal to 0.5 μ m in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid* -- An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection* -- Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator* -- That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level* -- The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on a blank (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm².

14. *Matrix* -- Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD* -- No structure detected.

16. *Operator* -- A person responsible for the TEM instrumental analysis of the sample.

17. *PCM* -- Phase contrast microscopy.

18. *SAED* -- Selected area electron diffraction.

19. *SEM* -- Scanning electron microscope.

20. *STEM* -- Scanning transmission electron microscope.

21. *Structure* -- a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm³* -- Structures per cubic centimeter.

23. *S/mm²* -- Structures per square millimeter.

24. *TEM* -- Transmission electron microscope. B. Sampling

1. The sampling agency must have written quality control procedures and documents which verify compliance.

2. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (References 1, 2, 3, and 5 of Unit II.J.).

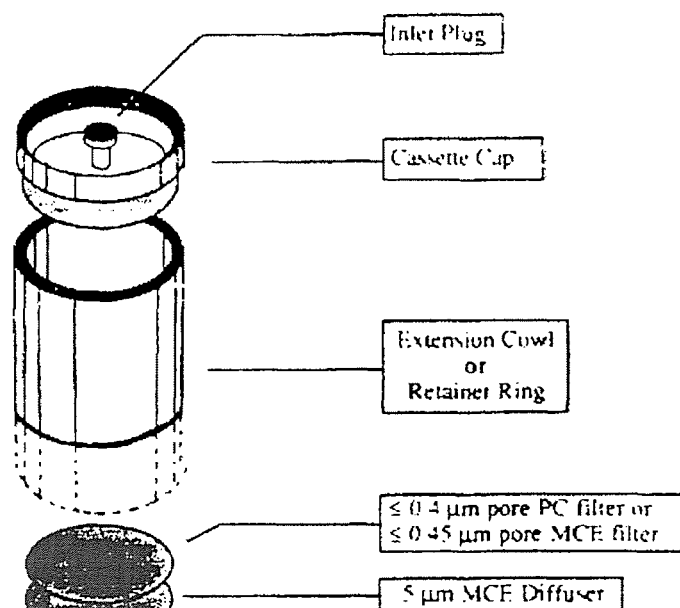
3. Sampling for airborne asbestos following an abatement action must use commercially available cassettes.

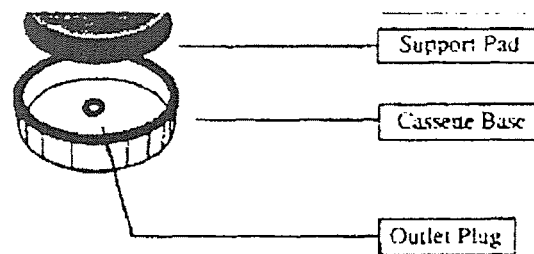
4. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm² for that same area is acceptable for this method.

5. Use sample collection filters which are either polycarbonate having a pore size less than or equal to 0.4 µm or mixed cellulose ester having a pore size less than or equal to 0.45 µm.

6. Place these filters in series with a 5.0 µm backup filter (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE 1--SAMPLING CASSETTE CONFIGURATION





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7. Reloading of used cassettes is not permitted.
8. Orient the cassette downward at approximately 45 degrees from the horizontal.
9. Maintain a log of all pertinent sampling information.
10. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter (not the filter which will be used in sampling) before and after the sampling operation.
11. Record all calibration information.
12. Ensure that the mechanical vibrations from the pump will be minimized to prevent transferral of vibration to the cassette.
13. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by damping out any pump action fluctuations if necessary.
14. The final plastic barrier around the abatement area remains in place for the sampling period.
15. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust. (See suggested protocol in Unit III.B.7.d.)
16. Select an appropriate flow rate equal to or greater than 1 liter per minute (L/min) or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.
17. A minimum of 13 samples are to be collected for each testing site consisting of the following:
 - a. A minimum of five samples per abatement area.
 - b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.
 - c. Two field blanks are to be taken by removing the cap for not more than 30 seconds and replacing it at the time of sampling before sampling is initiated at the following places:

- i. Near the entrance to each abatement area.
- ii. At one of the ambient sites. (DO NOT leave the field blanks open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

18. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

19. The following Table I specifies volume ranges to be used:

TABLE I--NUMBER OF 200 MESH EN GRID OPENINGS
(0.1497 MM²) THAT NEED TO BE ANALYZED TO
MAINTAIN SENSITIVITY OF 0.195 STRUCTURES, CC
BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 365 sq mm		Effective Filter Area 855 sq mm	
Volume (liters)	# of grid openings	Volume (liters)	# of grid openings
360	24	1,250	24
400	23	1,300	23
700	19	1,400	21
800	17	1,600	19
900	15	1,800	17
1,000	14	2,000	15
1,100	12	2,200	14
1,200	11	2,400	13
1,300	10	2,600	12
1,400	10	2,800	11
1,500	9	3,000	10
1,600	8	3,200	9
1,700	8	3,400	8
1,800	8	3,600	8
1,900	7	3,800	8
2,000	7	4,000	8
2,100	6	4,200	7
2,200	6	4,400	7
2,300	6	4,600	7
2,400	6	4,800	6
2,500	5	5,000	6
2,600	5	5,200	6
2,700	5	5,400	6
2,800	5	5,600	5
2,900	5	5,800	5
3,000	5	6,000	5
3,100	4	6,200	5
3,200	4	6,400	5
3,300	4	6,600	5
3,400	4	6,800	4
3,500	4	7,000	4
3,600	4	7,200	4
3,700	4	7,400	4
3,800	4	7,500	4

Note minimum volumes required:
25 mm - 500 liters
37 mm - 1250 liters

Filter diameter of 25 mm = effective area of 365 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

- 20. Ensure that the sampler is turned upright before interrupting the pump flow.
- 21. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory.
- 22. Ensure that the samples are stored in a secure and representative location.
- 23. Do not change containers if portions of these filters are taken for other purposes.
- 24. A summary of Sample Data Quality Objectives is shown in the following Table II:

TABLE 11--SUMMARY OF SAMPLING METHOD DATA QUALITY OBJECTIVES

This table summarizes the data quality objectives from the performance of this method in terms of precision, accuracy, consistency, representativeness, and comparability. These objectives are assured by the periodic control checks and reference checks (listed here and described in the text of the method).

QA Objective	QC Check	Frequency	Confidence Expectation
Sampling materials	Sealed blanks	1 per 100 sites	95%
Sample preservation	Field blanks	2 per 100 sites	95%
	Blank subsamples	Review and analyze each field series	95%
Sample recovery	Review of laboratory custody record	Each sample	95% complete
Sample shipment	Review of shipping report	Each sample	95% complete

C. Sample Shipment

Ship bulk samples to the analytical laboratory in a separate container from air samples. D. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected. E. Sample Preparation

1. All sample preparation and analysis shall be performed by a laboratory independent of the abatement contractor.

2. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them into the clean room facility.

3. Perform sample preparation in a well-equipped clean facility.

>Note: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA-filtered. The cumulative analytical blank concentration must average less than 18 s/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm² for that same area.

4. Preparation areas for air samples must not only be separated from preparation areas for bulk samples, but they must be prepared in separate rooms.

5. Direct preparation techniques are required. The object is to produce an intact film containing the particulates of the filter surface which is sufficiently clear for TEM analysis.

a. TEM Grid Opening Area measurement must be done as follows:

i. The filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique.

ii. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass and examining it under the PCM. Use a calibrated graticule to measure the average field

diameters. From the data, calculate the field area for an average grid opening.

iii. Measurements can also be made on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

b. TEM specimen preparation from polycarbonate (PC) filters. Procedures as described in Unit III.G. or other equivalent methods may be used.

c. TEM specimen preparation from mixed cellulose ester (MCE) filters.

i. Filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique or the Burdette procedure (Ref. 7 of Unit II.J.)

ii. Plasma etching of the collapsed filter is required. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for the particulate asher and operating conditions will then be set such that a 1-2 μm (10 percent) layer of collapsed surface will be removed.

iii. Procedures as described in Unit III. or other equivalent methods may be used to prepare samples.

F. TEM Method

1. An 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations is required. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely for magnification and camera constant.

2. *Determination of Camera Constant and ED Pattern Analysis.* The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulate. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one-half the diameter of the rings times the interplanar spacing of the ring being measured.

3. *Magnification Calibration.* The magnification calibration must be done at the fluorescent screen. The TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica (e.g., one containing 2,160

lines/mm). Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric). A logbook must be maintained, and the dates of calibration and the values obtained must be recorded. The frequency of calibration depends on the past history of the particular microscope. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate a eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

4. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory.

5. Microscope settings: 80-120 kV, grid assessment 250-1,000X, then 15,000-20,000X screen magnification for analysis.

6. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

7. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading must not be analyzed.

8. Reject the grid if:

- a. Less than 50 percent of the grid openings covered by the replica are intact.
- b. The replica is doubled or folded.
- c. The replica is too dark because of incomplete dissolution of the filter.

9. Recording Rules.

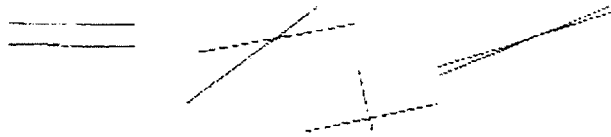
a. Any continuous grouping of particles in which an asbestos fiber with an aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 μm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. An intersection is a nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. See the following Figure 2:

FIGURE 2--COUNTING GUIDELINES USED IN DETERMINING ASBESTOS STRUCTURES

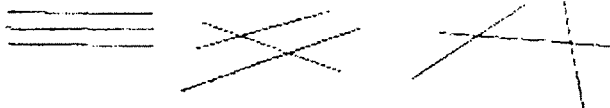
Diagram 2: 1 Fiber, 1 Separation, no intersections.



Count as 1 fiber to space between fibers or greater than width of 1 fiber diameter or number of intersections is equal to or less than 1.



Count as 1 structure if space between fibers is greater than width of 1 fiber diameter or if the number of intersections is equal to or less than 1.

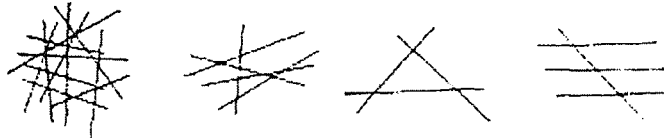


Count bundles as 1 structure; 1 or more parallel fibrils less than 1 fiber diameter separation.

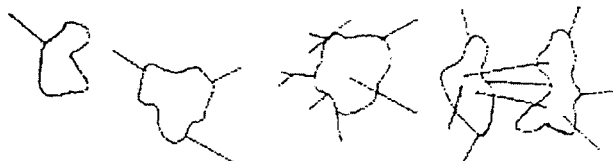


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Count clusters as 1 structure; fibers having greater than or equal to 3 intersections.



Count matrix as 1 structure.



DO NOT COUNT AS STRUCTURES:



Fiber protrusion
<5:1 Aspect Ratio

No fiber protrusion

Fiber protrusion
>0.5 micrometer

— <0.5 micrometer in length
— <5:1 Aspect Ratio

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i. *Fiber*. A structure having a minimum length greater than or equal to 0.5 μm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle*. A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

b. Separate categories will be maintained for fibers less than 5 μm and for fibers equal to or greater than 5 μm in length.

c. Record NSD when no structures are detected in the field.

d. Visual identification of electron diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm² concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

e. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. In the event that examination of the pattern by a qualified individual indicates that the pattern has been misidentified visually, the client shall be contacted.

f. Energy Dispersive X-ray Analysis (EDXA) is required of all amphiboles which would cause the analysis results to exceed the 70 s/mm² concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

g. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm² concentration, the fact that they are not asbestos must be confirmed by EDXA or measurement of a zone axis diffraction pattern.

h. Fibers classified as chrysotile must be identified by diffraction or X-ray analysis and recorded on a count sheet. X-ray analysis alone can be used only after 70 s/mm² have been exceeded for a particular sample.

i. Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used only after 70 s/mm² have been exceeded for a particular sample.)

j. If a diffraction pattern was recorded on film, record the micrograph number on the count sheet.

k. If an electron diffraction was attempted but no pattern was observed, record N on the count sheet.

l. If an EDXA spectrum was attempted but not observed, record N on the count sheet.

m. If an X-ray analysis spectrum is stored, record the file and disk number on the count sheet.

10. Classification Rules.

a. *Fiber*. A structure having a minimum length greater than or equal to 0.5 μm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

b. *Bundle*. A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

c. *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

d. *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

11. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid holder. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request. G. Sample Analytical Sequence

1. Under the present sampling requirements a minimum of 13 samples is to be collected for the clearance testing of an abatement site. These include five abatement area samples, five ambient samples, two field blanks, and one sealed blank.

2. Carry out visual inspection of work site prior to air monitoring.

3. Collect a minimum of 5 air samples inside the work site and 5 samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

4. Remaining steps in the analytical sequence are contained in Unit IV of this Appendix. H. Reporting

1. The following information must be reported to the client for each sample analyzed:

a. Concentration in structures per square millimeter and structures per cubic centimeter.

b. Analytical sensitivity used for the analysis.

c. Number of asbestos structures.

d. Area analyzed.

e. Volume of air sampled (which must be initially supplied to lab by client).

- f. Copy of the count sheet must be included with the report.
- g. Signature of laboratory official to indicate that the laboratory met specifications of the method.
- h. Report form must contain official laboratory identification (e.g., letterhead).
- i. Type of asbestos. I. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards are to be performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Confidence Estimate
Sample receiving	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 gridlets of 1000 or 1 opening/sample	100%
	Special clean area monitoring	After cleaning or service	Meet specs. or reject
	Laboratory blank	1 per prep series or 10%	Meet specs. or standardize error
	Plasma each blank	1 per 20 samples	75%
Sample analysis	Multiple prep (3 per sample)	Each sample	One with error of 13 complete grid size
	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
	ED calibration by zephiran line	Daily	95%
	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10%; read 1 per 20 samples	Meet specs. or standardize error
Performance check	Replicate counting (measure of precision)	1 per 100 samples	1.3 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 (asbestos Ref 1876) (measure of accuracy and comparability)	1 per analyst per year	1.3 x Poisson Std. Dev.
	Data entry review (data validation and measure of completeness)	Each sample	95%
	Review and verify ID of known difference pattern of structure	1 per 5 samples	80% accuracy
	Manual calculation of automated data reduction procedure or independent recalculation of hand-calculated data	1 per 100 samples	85%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks. Testing with blanks must also be done after cleaning or servicing the room.
4. Prepare multiple grids of each sample.
5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results. If there are more than 53 fibers/mm² per 10 200-mesh grid openings, the system must be checked for possible sources of contamination.
6. Perform a system check on the transmission electron microscope daily.
7. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III under Unit II.I.
8. Ensure qualified operator performance by evaluation of replicate analysis and standard sample comparisons as set forth in Table III under Unit II.I.
9. Validate all data entries.
10. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III under Unit II.I.
11. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns.
12. Appropriate logs or records must be maintained by the analytical laboratory verifying that it is in compliance with the mandatory quality assurance procedures. J. References

For additional background information on this method, the following references should be consulted.

1. "Guidance for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.
2. "Measuring Airborne Asbestos Following an Abatement Action," USEPA, Office of Pollution Prevention and Toxics, EPA 600/4-85-049, 1985.
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5. Quality Assurance Handbook for Air Pollution Measurement System. Ambient Air Methods, EPA 600/4-77-027a, USEPA, Office of Research and Development, 1977.

6. Method 2A: Direct Measurement of Gas Volume through Pipes and Small Ducts. 40 CFR Part 60 Appendix A.

7. Burdette, G.J., Health & Safety Exec. Research & Lab. Services Div., London, "Proposed Analytical Method for Determination of Asbestos in Air."

8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc., "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters," WERL SOP 87-1. March 5, 1987.

9. NIOSH Method 7402 for Asbestos Fibers, 12-11-86 Draft.

10. Yamate, G., Agarwall, S.C., Gibbons, R.D., IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy," Draft report, USEPA Contract 68-02-3266, July 1984.

11. "Guidance to the Preparation of Quality Assurance Project Plans," USEPA, Office of Pollution Prevention and Toxics, 1984.

III. Nonmandatory Transmission Electron Microscopy Method

A. Definitions of Terms

1. *Analytical sensitivity* -- Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 s/cm³.

2. *Asbestiform* -- A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.

3. *Aspect ratio* -- A ratio of the length to the width of a particle. Minimum aspect ratio as defined by this method is equal to or greater than 5:1.

4. *Bundle* -- A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area* -- A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm² in an area of 0.057 mm² (nominally 10 200 mesh grid openings) and a maximum of 53 structures/mm² for no more than one single preparation for that same area.

6. *Cluster* -- A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED* -- Electron diffraction.

8. *EDXA* -- Energy dispersive X-ray analysis.
9. *Fiber* -- A structure greater than or equal to 0.5 μm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.
10. *Grid* -- An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.
11. *Intersection* -- Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.
12. *Laboratory sample coordinator* -- That person responsible for the conduct of sample handling and the certification of the testing procedures.
13. *Filter background level* -- The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on blanks (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/ mm^2 .
14. *Matrix* -- Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.
15. *NSD* -- No structure detected.
16. *Operator* -- A person responsible for the TEM instrumental analysis of the sample.
17. *PCM* -- Phase contrast microscopy.
18. *SAED* -- Selected area electron diffraction.
19. *SEM* -- Scanning electron microscope.
20. *STEM* -- Scanning transmission electron microscope.
21. *Structure* -- a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.
22. *S/cm³* -- Structures per cubic centimeter.
23. *S/mm²* -- Structures per square millimeter.
24. *TEM* -- Transmission electron microscope. B. Sampling
 1. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (See References 1, 2, and 5 of Unit III.L.) Special precautions should be taken to avoid contamination of the sample. For example, materials that have not been prescreened for their asbestos background content should not be used; also, sample handling procedures which do not take cross contamination possibilities into account should not be used.

2. Material and supply checks for asbestos contamination should be made on all critical supplies, reagents, and procedures before their use in a monitoring study.

3. Quality control and quality assurance steps are needed to identify problem areas and isolate the cause of the contamination (see Reference 5 of Unit III.L.). Control checks shall be permanently recorded to document the quality of the information produced. The sampling firm must have written quality control procedures and documents which verify compliance. Independent audits by a qualified consultant or firm should be performed once a year. All documentation of compliance should be retained indefinitely to provide a guarantee of quality. A summary of Sample Data Quality Objectives is shown in Table II of Unit II.B.

4. Sampling materials.

a. Sample for airborne asbestos following an abatement action using commercially available cassettes.

b. Use either a cowl or a filter-retaining middle piece. Conductive material may reduce the potential for particulates to adhere to the walls of the cowl.

c. Cassettes must be verified as "clean" prior to use in the field. If packaged filters are used for loading or preloaded cassettes are purchased from the manufacturer or a distributor, the manufacturer's name and lot number should be entered on all field data sheets provided to the laboratory, and are required to be listed on all reports from the laboratory.

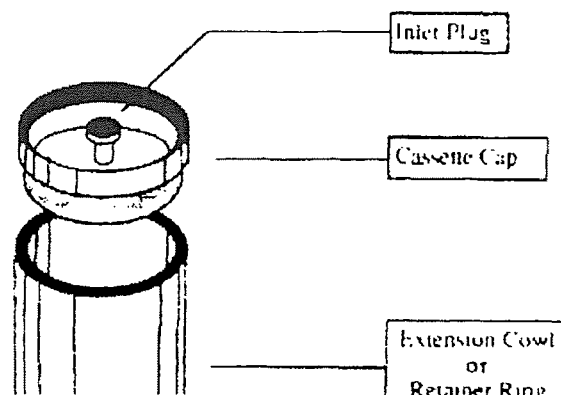
d. Assemble the cassettes in a clean facility (See definition of clean area under Unit III.A.).

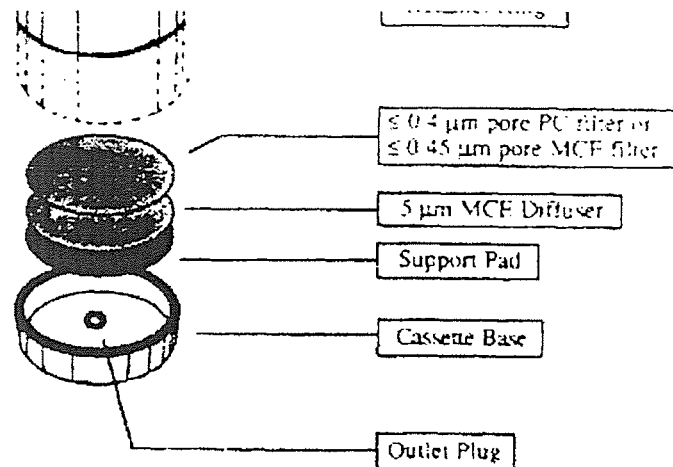
e. Reloading of used cassettes is not permitted.

f. Use sample collection filters which are either polycarbonate having a pore size of less than or equal to $0.4\ \mu\text{m}$ or mixed cellulose ester having a pore size of less than or equal to $0.45\ \mu\text{m}$.

g. Place these filters in series with a backup filter with a pore size of $5.0\ \mu\text{m}$ (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE 1--SAMPLING CASSETTE CONFIGURATION





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- h. When polycarbonate filters are used, position the highly reflective face such that the incoming particulate is received on this surface.
 - i. Seal the cassettes to prevent leakage around the filter edges or between cassette part joints. A mechanical press may be useful to achieve a reproducible leak-free seal. Shrink fit gel-bands may be used for this purpose and are available from filter manufacturers and their authorized distributors.
 - j. Use wrinkle-free loaded cassettes in the sampling operation.
5. Pump setup.
- a. Calibrate the sampling pump over the range of flow rates and loads anticipated for the monitoring period with this flow measuring device in series. Perform this calibration using guidance from EPA Method 2A each time the unit is sent to the field (See Reference 6 of Unit III.L.).
 - b. Configure the sampling system to preclude pump vibrations from being transmitted to the cassette by using a sampling stand separate from the pump station and making connections with flexible tubing.
 - c. Maintain continuous smooth flow conditions by damping out any pump action fluctuations if necessary.
 - d. Check the sampling system for leaks with the end cap still in place and the pump operating before initiating sample collection. Trace and stop the source of any flow indicated by the flowmeter under these conditions.
 - e. Select an appropriate flow rate equal to or greater than 1 L/min or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.
 - f. Orient the cassette downward at approximately 45 degrees from the horizontal.

g. Maintain a log of all pertinent sampling information, such as pump identification number, calibration data, sample location, date, sample identification number, flow rates at the beginning, middle, and end, start and stop times, and other useful information or comments. Use of a sampling log form is recommended. See the following Figure 2:

FIGURE 2--SAMPLING LOG FORM

Sample Number	Location of Sample	Pump I.D.	Start Time	Middle Time	End Time	Flow Rate

Inspector: _____ Date: _____

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- h. Initiate a chain of custody procedure at the start of each sampling, if this is requested by the client.
- i. Maintain a close check of all aspects of the sampling operation on a regular basis.
- j. Continue sampling until at least the minimum volume is collected, as specified in the following Table I:

TABLE 1--NUMBER OF 200 MESH EM GRID OPENINGS
(0.0057 MM=1 THAT NEED TO BE ANALYZED TO
MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC
BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 385 sq mm		Effective Filter Area 855 sq mm	
Volume (liters)	# of grid openings	Volume (liters)	# of grid openings
560	24	1,250	24
600	23	1,300	23
700	19	1,400	21
800	17	1,600	19
900	15	1,800	17
1,000	14	2,000	15
1,100	12	2,200	14
1,200	11	2,400	13
1,300	10	2,600	12
1,400	10	2,800	11
1,500	9	3,000	10
1,600	8	3,200	9
1,700	8	3,400	9
1,800	8	3,600	8
1,900	7	3,800	8
2,000	7	4,000	8
2,100	5	4,200	7
2,200	6	4,400	7
2,300	5	4,600	7
2,400	6	4,800	6
2,500	5	5,000	6
2,600	5	5,200	6
2,700	5	5,400	6
2,800	5	5,600	5
2,900	5	5,800	5
3,000	5	6,000	5
3,100	4	6,200	5
3,200	4	6,400	5
3,300	4	6,600	5
3,400	4	6,800	4
3,500	4	7,000	4
3,600	4	7,200	4
3,700	4	7,400	4
3,800	4	7,600	4

Note: minimum volumes required:
25 mm = 580 liters
37 mm = 1250 liters

Fiber diameter of 25 mm = effective area of 385 sq mm
Fiber diameter of 37 mm = effective area of 855 sq mm

k. At the conclusion of sampling, turn the cassette upward before stopping the flow to minimize possible particle loss. If the sampling is resumed, restart the flow before reorienting the cassette downward. Note the condition of the filter at the conclusion of sampling.

l. Double check to see that all information has been recorded on the data collection forms and that the cassette is securely closed and appropriately identified using a waterproof label. Protect cassettes in individual clean resealed polyethylene bags. Bags are to be used for storing cassette caps when they are removed for sampling purposes. Caps and plugs should only be removed or replaced using clean hands or clean disposable plastic gloves.

m. Do not change containers if portions of these filters are taken for other purposes.

6. Minimum sample number per site. A minimum of 13 samples are to be collected for each testing consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 sec and replacing it at the time of sampling before sampling is initiated at the following places:

- i. Near the entrance to each ambient area.
- ii. At one of the ambient sites.

(**Note:** Do not leave the blank open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

7. Abatement area sampling.

a. Conduct final clearance sampling only after the primary containment barriers have been removed; the abatement area has been thoroughly dried; and, it has passed visual inspection tests by qualified personnel. (See Reference 1 of Unit III.L.)

b. Containment barriers over windows, doors, and air passageways must remain in place until the TEM clearance sampling and analysis is completed and results meet clearance test criteria. The final plastic barrier remains in place for the sampling period.

c. Select sampling sites in the abatement area on a random basis to provide unbiased and representative samples.

d. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust.

i. Equipment used in aggressive sampling such as a leaf blower and/or fan should be properly cleaned and decontaminated before use.

ii. Air filtration units shall remain on during the air monitoring period.

iii. Prior to air monitoring, floors, ceiling and walls shall be swept with the exhaust of a minimum one (1) horsepower leaf blower.

iv. Stationary fans are placed in locations which will not interfere with air monitoring equipment. Fan air is directed toward the ceiling. One fan shall be used for each 10,000 ft³ of worksite.

v. Monitoring of an abatement work area with high-volume pumps and the use of circulating fans will require electrical power. Electrical outlets in the abatement area may be used if available. If no such outlets are available, the equipment must be supplied with electricity by the use of extension cords and strip plug units. All electrical power supply equipment of this type must be approved Underwriter Laboratory equipment that has not been modified. All wiring must be grounded. Ground fault interrupters should be used. Extreme care must be taken to clean up any residual water and ensure that electrical equipment does not become wet while operational.

vi. Low volume pumps may be carefully wrapped in 6-mil polyethylene to insulate the pump from the air. High volume pumps cannot be sealed in this manner since the heat of the motor may melt the plastic. The pump exhausts should be kept free.

vii. If recleaning is necessary, removal of this equipment from the work area must be handled with care. It is not possible to completely decontaminate the pump motor and parts since these areas cannot be wetted. To minimize any problems in this area, all equipment such as fans and pumps should be carefully wet wiped prior to removal from the abatement area. Wrapping and sealing low volume pumps in 6-mil polyethylene will provide easier decontamination of this equipment. Use of clean water and disposable wipes should be available for this purpose.

e. Pump flow rate equal to or greater than 1 L/min or less than 10 L/min may be used for 25 mm cassettes. The larger cassette diameters may have comparably increased flow.

f. Sample a volume of air sufficient to ensure the minimum quantitation limits. (See Table I of Unit III.B.5.j.)

8. Ambient sampling.

a. Position ambient samplers at locations representative of the air entering the abatement site. If makeup air entering the abatement site is drawn from another area of the building which is outside of the abatement area, place the pumps in the building, pumps should be placed out of doors located near the building and away from any obstructions that may influence wind patterns. If construction is in progress immediately outside the enclosure, it may be necessary to select another ambient site. Samples should be representative of any air entering the work site.

b. Locate the ambient samplers at least 3 ft apart and protect them from adverse weather conditions.

c. Sample same volume of air as samples taken inside the abatement site. C. Sample Shipment

1. Ship bulk samples in a separate container from air samples. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.

2. Select a rigid shipping container and pack the cassettes upright in a noncontaminating nonfibrous medium such as a bubble pack. The use of resealable polyethylene bags may help to prevent jostling of individual cassettes.

3. Avoid using expanded polystyrene because of its static charge potential. Also avoid using particle-based packaging materials because of possible contamination.

4. Include a shipping bill and a detailed listing of samples shipped, their descriptions and all identifying numbers or marks, sampling data, shipper's name, and contact information. For each sample set, designate which are the ambient samples, which are the abatement area samples, which are the field blanks, and which is the sealed blank if sequential analysis is to be performed.

5. Hand-carry samples to the laboratory in an upright position if possible; otherwise choose that mode of transportation least likely to jar the samples in transit.

6. Address the package to the laboratory sample coordinator by name when known and alert him or her of the package description, shipment mode, and anticipated arrival as part of the chain of custody and sample tracking procedures. This will also help the laboratory schedule timely analysis for the samples when they are received. D. Quality Control/Quality Assurance Procedures (Data Quality

Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined, and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the text below.

1. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a maximum of 53 s/mm² for that same area for any single preparation is acceptable for this method.
2. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter -- not the filter which will be used in sampling -- before and after the sampling operation.
3. Record all calibration information with the data to be used on a standard sampling form.
4. Ensure that the samples are stored in a secure and representative location.
5. Ensure that mechanical calibrations from the pump will be minimized to prevent transferral of vibration to the cassette.
6. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by installing a damping chamber if necessary.
7. Open a loaded cassette momentarily at one of the indoor sampling sites when sampling is initiated. This sample will serve as an indoor field blank.
8. Open a loaded cassette momentarily at one of the outdoor sampling sites when sampling is initiated. This sample will serve as an outdoor field blank.
9. Carry a sealed blank into the field with each sample series. Do not open this cassette in the field.
10. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.
11. Ensure that the sampler is turned upright before interrupting the pump flow.
12. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory. E. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.
2. Adhere to the following procedures to ensure both the continued chain-of-custody and the accountability of all samples passing through the laboratory:
 - a. Note the condition of the shipping package and data written on it upon receipt.
 - b. Retain all bills of lading or shipping slips to document the shipper and delivery time.
 - c. Examine the chain-of-custody seal, if any, and the package for its integrity.
 - d. If there has been a break in the seal or substantive damage to the package, the sample coordinator shall immediately notify the shipper and a responsible laboratory manager before any action is taken to unpack the shipment.
 - e. Packages with significant damage shall be accepted only by the responsible laboratory manager after discussions with the client.
3. Unwrap the shipment in a clean, uncluttered facility. The sample coordinator or his or her designee will record the contents, including a description of each item and all identifying numbers or marks. A Sample Receiving Form to document this information is attached for use when necessary. (See the following Figure 3.)

FIGURE 3--SAMPLE RECEIVING FORM

Date of package delivery _____	Package shipped from _____
Carrier _____	Shipping bill retained _____
*Condition of package on receipt _____	
*Condition of custody seal _____	
Number of samples received _____	Shipping manifest attached _____
Purchase Order No. _____	Project I.D. _____
Comments _____	

No.	Description	Sampling Medium		Sampled Volume (L)	Receiving Date	Assay Date
		PC	MC			
1	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____	_____
5	_____	_____	_____	_____	_____	_____
6	_____	_____	_____	_____	_____	_____
7	_____	_____	_____	_____	_____	_____
8	_____	_____	_____	_____	_____	_____
9	_____	_____	_____	_____	_____	_____
10	_____	_____	_____	_____	_____	_____
11	_____	_____	_____	_____	_____	_____
12	_____	_____	_____	_____	_____	_____
13	_____	_____	_____	_____	_____	_____

(Use as many additional sheets as needed.)

Comments _____

Date of acceptance into sample bank _____

Signature of chain-of-custody recipient _____

LABORATORY OF SAMPLES
"Note" If the package has sustained substantial damage or the custody seal is broken, stop and contact the project manager and the shipper.

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Note: The person breaking the chain-of-custody seal and itemizing the contents assumes responsibility for the shipment and signs documents accordingly.

4. Assign a laboratory number and schedule an analysis sequence.

5. Manage all chain-of-custody samples within the laboratory such that their integrity can be ensured and documented. F. Sample Preparation

1. Personnel not affiliated with the Abatement Contractor shall be used to prepare samples and conduct TEM analysis. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them to the clean sample preparation facility.

2. Perform sample preparation in a well-equipped clean facility.

Note: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA filtered. The cumulative analytical blank concentration must average less than 18 s/mm² in an area of 0.057 s/mm² (nominally 10 200-mesh grid openings) with no more than one single preparation to exceed 53 s/mm² for that same area.

3. Preparation areas for air samples must be separated from preparation areas for bulk samples. Personnel must not prepare air samples if they have previously been preparing bulk samples without performing appropriate personal hygiene procedures, i.e., clothing change, showering, etc.

4. *Preparation.* Direct preparation techniques are required. The objective is to produce an intact carbon film containing the particulates from the filter surface which is sufficiently clear for TEM analysis. Currently recommended direct preparation procedures for polycarbonate (PC) and mixed cellulose ester (MCE) filters are described in Unit III.F.7. and 8. Sample preparation is a subject requiring additional research. Variation on those steps which do not substantively change the procedure, which improve filter clearing or which reduce contamination problems in a laboratory are permitted.

a. Use only TEM grids that have had grid opening areas measured according to directions in Unit III.J.

b. Remove the inlet and outlet plugs prior to opening the cassette to minimize any pressure differential that may be present.

c. Examples of techniques used to prepare polycarbonate filters are described in Unit III.F.7.

d. Examples of techniques used to prepare mixed cellulose ester filters are described in Unit III.F.8.

- e. Prepare multiple grids for each sample.
- f. Store the three grids to be measured in appropriately labeled grid holders or polyethylene capsules.

5. Equipment.

- a. Clean area.
- b. Tweezers. Fine-point tweezers for handling of filters and TEM grids.
- c. Scalpel Holder and Curved No. 10 Surgical Blades.
- d. Microscope slides.
- e. Double-coated adhesive tape.
- f. Gummed page reinforcements.
- g. Micro-pipet with disposal tips 10 to 100 μ L variable volume.
- h. Vacuum coating unit with facilities for evaporation of carbon. Use of a liquid nitrogen cold trap above the diffusion pump will minimize the possibility of contamination of the filter surface by oil from the pumping system. The vacuum-coating unit can also be used for deposition of a thin film of gold.
- i. *Carbon rod electrodes*. Spectrochemically pure carbon rods are required for use in the vacuum evaporator for carbon coating of filters.
- j. *Carbon rod sharpener*. This is used to sharpen carbon rods to a neck. The use of necked carbon rods (or equivalent) allows the carbon to be applied to the filters with a minimum of heating.
- k. *Low-temperature plasma asher*. This is used to etch the surface of collapsed mixed cellulose ester (MCE) filters. The asher should be supplied with oxygen, and should be modified as necessary to provide a throttle or bleed valve to control the speed of the vacuum to minimize disturbance of the filter. Some early models of ashers admit air too rapidly, which may disturb particulates on the surface of the filter during the etching step.
- l. *Glass petri dishes, 10 cm in diameter, 1 cm high*. For prevention of excessive evaporation of solvent when these are in use, a good seal must be provided between the base and the lid. The seal can be improved by grinding the base and lid together with an abrasive grinding material.
- m. Stainless steel mesh.
- n. Lens tissue.
- o. Copper 200-mesh TEM grids, 3 mm in diameter, or equivalent.
- p. Gold 200-mesh TEM grids, 3 mm in diameter, or equivalent.

- q. Condensation washer.
- r. Carbon-coated, 200-mesh TEM grids, or equivalent.
- s. Analytical balance, 0.1 mg sensitivity.
- t. Filter paper, 9 cm in diameter.
- u. Oven or slide warmer. Must be capable of maintaining a temperature of 65-70 °C.
- v. Polyurethane foam, 6 mm thickness.
- w. Gold wire for evaporation.

6. Reagents.

- a. *General.* A supply of ultra-clean, fiber-free water must be available for washing of all components used in the analysis. Water that has been distilled in glass or filtered or deionized water is satisfactory for this purpose. Reagents must be fiber-free.
- b. Polycarbonate preparation method -- chloroform.
- c. Mixed Cellulose Ester (MCE) preparation method -- acetone or the Burdette procedure (Ref. 7 of Unit III.L.).

7. TEM specimen preparation from polycarbonate filters.

- a. *Specimen preparation laboratory.* It is most important to ensure that contamination of TEM specimens by extraneous asbestos fibers is minimized during preparation.
- b. Cleaning of sample cassettes. Upon receipt at the analytical laboratory and before they are taken into the clean facility or laminar flow hood, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces.
- c. Preparation of the carbon evaporator. If the polycarbonate filter has already been carbon-coated prior to receipt, the carbon coating step will be omitted, unless the analyst believes the carbon film is too thin. If there is a need to apply more carbon, the filter will be treated in the same way as an uncoated filter. Carbon coating must be performed with a high-vacuum coating unit. Units that are based on evaporation of carbon filaments in a vacuum generated only by an oil rotary pump have not been evaluated for this application, and must not be used. The carbon rods should be sharpened by a carbon rod sharpener to necks of about 4 mm long and 1 mm in diameter. The rods are installed in the evaporator in such a manner that the points are approximately 10 to 12 cm from the surface of a microscope slide held in the rotating and tilting device.
- d. Selection of filter area for carbon coating. Before preparation of the filters, a 75 mm x 50 mm microscope slide is washed and dried. This slide is used to support strips of filter during the carbon evaporation. Two parallel strips of double-sided adhesive tape are applied along the length of the slide. Polycarbonate filters are easily stretched during handling, and cutting of areas for further

preparation must be performed with great care. The filter and the MCE backing filter are removed together from the cassette and placed on a cleaned glass microscope slide. The filter can be cut with a curved scalpel blade by rocking the blade from the point placed in contact with the filter. The process can be repeated to cut a strip approximately 3 mm wide across the diameter of the filter. The strip of polycarbonate filter is separated from the corresponding strip of backing filter and carefully placed so that it bridges the gap between the adhesive tape strips on the microscope slide. The filter strip can be held with fine-point tweezers and supported underneath by the scalpel blade during placement on the microscope slide. The analyst can place several such strips on the same microscope slide, taking care to rinse and wet-wipe the scalpel blade and tweezers before handling a new sample. The filter strips should be identified by etching the glass slide or marking the slide using a marker insoluble in water and solvents. After the filter strip has been cut from each filter, the residual parts of the filter must be returned to the cassette and held in position by reassembly of the cassette. The cassette will then be archived for a period of 30 days or returned to the client upon request.

e. Carbon coating of filter strips. The glass slide holding the filter strips is placed on the rotation-tilting device, and the evaporator chamber is evacuated. The evaporation must be performed in very short bursts, separated by some seconds to allow the electrodes to cool. If evaporation is too rapid, the strips of polycarbonate filter will begin to curl, which will lead to cross-linking of the surface material and make it relatively insoluble in chloroform. An experienced analyst can judge the thickness of carbon film to be applied, and some test should be made first on unused filters. If the film is too thin, large particles will be lost from the TEM specimen, and there will be few complete and undamaged grid openings on the specimen. If the coating is too thick, the filter will tend to curl when exposed to chloroform vapor and the carbon film may not adhere to the support mesh. Too thick a carbon film will also lead to a TEM image that is lacking in contrast, and the ability to obtain ED patterns will be compromised. The carbon film should be as thin as possible and remain intact on most of the grid openings of the TEM specimen intact.

f. Preparation of the Jaffe washer. The precise design of the Jaffe washer is not considered important, so any one of the published designs may be used. A washer consisting of a simple stainless steel bridge is recommended. Several pieces of lens tissue approximately 1.0 cm x 0.5 cm are placed on the stainless steel bridge, and the washer is filled with chloroform to a level where the meniscus contacts the underside of the mesh, which results in saturation of the lens tissue. See References 8 and 10 of Unit III.L.

g. Placing of specimens into the Jaffe washer. The TEM grids are first placed on a piece of lens tissue so that individual grids can be picked up with tweezers. Using a curved scalpel blade, the analyst excises three 3 mm square pieces of the carbon-coated polycarbonate filter from the filter strip. The three squares are selected from the center of the strip and from two points between the outer periphery of the active surface and the center. The piece of filter is placed on a TEM specimen grid with the shiny side of the TEM grid facing upwards, and the whole assembly is placed boldly onto the saturated lens tissue in the Jaffe washer. If carbon-coated grids are used, the filter should be placed carbon-coated side down. The three excised squares of filters are placed on the same piece of lens tissue. Any number of separate pieces of lens tissue may be placed in the same Jaffe washer. The lid is then placed on the Jaffe washer, and the system is allowed to stand for several hours, preferably overnight.

h. *Condensation washing.* It has been found that many polycarbonate filters will not dissolve completely in the Jaffe washer, even after being exposed to chloroform for as long as 3 days. This problem becomes more serious if the surface of the filter was overheated during the carbon

evaporation. The presence of undissolved filter medium on the TEM preparation leads to partial or complete obscuration of areas of the sample, and fibers that may be present in these areas of the specimen will be overlooked; this will lead to a low result. Undissolved filter medium also compromises the ability to obtain ED patterns. Before they are counted, TEM grids must be examined critically to determine whether they are adequately cleared of residual filter medium. It has been found that condensation washing of the grids after the initial Jaffe washer treatment, with chloroform as the solvent, clears all residual filter medium in a period of approximately 1 hour. In practice, the piece of lens tissue supporting the specimen grids is transferred to the cold finger of the condensation washer, and the washer is operated for about 1 hour. If the specimens are cleared satisfactorily by the Jaffe washer alone, the condensation washer step may be unnecessary.

8. TEM specimen preparation from MCE filters.

- a. This method of preparing TEM specimens from MCE filters is similar to that specified in NIOSH Method 7402. See References 7, 8, and 9 of Unit III.L.
- b. Upon receipt at the analytical laboratory, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces before entering the clean sample preparation area.
- c. Remove a section from any quadrant of the sample and blank filters.
- d. Place the section on a clean microscope slide. Affix the filter section to the slide with a gummed paper reinforcement or other suitable means. Label the slide with a water and solvent-proof marking pen.
- e. Place the slide in a petri dish which contains several paper filters soaked with 2 to 3 mL acetone. Cover the dish. Wait 2 to 4 minutes for the sample filter to fuse and clear.
- f. Plasma etching of the collapsed filter is required.
 - i. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. This is one area of the method that requires further evaluation. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for a particular asher and operating conditions will then be set such that a 1-2 μm (10 percent) layer of collapsed surface will be removed.
 - ii. Place the slide containing the collapsed filters into a low-temperature plasma asher, and etch the filter.
- g. Transfer the slide to a rotating stage inside the bell jar of a vacuum evaporator. Evaporate a 1 mm x 5 mm section of graphite rod onto the cleared filter. Remove the slide to a clean, dry, covered petri dish.
- h. Prepare a second petri dish as a Jaffe washer with the wicking substrate prepared from filter or lens paper placed on top of a 6 mm thick disk of clean spongy polyurethane foam. Cut a V-notch on the

edge of the foam and filter paper. Use the V-notch as a reservoir for adding solvent. The wicking substrate should be thin enough to fit into the petri dish without touching the lid.

i. Place carbon-coated TEM grids face up on the filter or lens paper. Label the grids by marking with a pencil on the filter paper or by putting registration marks on the petri dish lid and marking with a waterproof marker on the dish lid. In a fume hood, fill the dish with acetone until the wicking substrate is saturated. The level of acetone should be just high enough to saturate the filter paper without creating puddles.

j. Remove about a quarter section of the carbon-coated filter samples from the glass slides using a surgical knife and tweezers. Carefully place the section of the filter, carbon side down, on the appropriately labeled grid in the acetone-saturated petri dish. When all filter sections have been transferred, slowly add more solvent to the wedge-shaped trough to bring the acetone level up to the highest possible level without disturbing the sample preparations. Cover the petri dish. Elevate one side of the petri dish by placing a slide under it. This allows drops of condensed solvent vapors to form near the edge rather than in the center where they would drip onto the grid preparation. G. TEM Method

1. *Instrumentation.*

a. Use an 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely (see Unit III.J.) for magnification and camera constant.

b. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory. This must be an Energy Dispersive X-ray Detector mounted on TEM column and associated hardware/software to collect, save, and read out spectral information. Calibration of Multi-Channel Analyzer shall be checked regularly for Al at 1.48 KeV and Cu at 8.04 KeV, as well as the manufacturer's procedures.

i. Standard replica grating may be used to determine magnification (e.g., 2160 lines/mm).

ii. Gold standard may be used to determine camera constant.

c. Use a specimen holder with single tilt and/or double tilt capabilities.

2. *Procedure.*

a. Start a new Count Sheet for each sample to be analyzed. Record on count sheet: analyst's initials and date; lab sample number; client sample number microscope identification; magnification for analysis; number of predetermined grid openings to be analyzed; and grid identification. See the following Figure 4:

(1) Less than 50 percent of the grid openings covered by the replica are intact.

(2) It is doubled or folded.

(3) It is too dark because of incomplete dissolution of the filter.

iv. If the grid is rejected, load the next sample grid.

v. If the grid is acceptable, continue on to Step 6 if mapping is to be used; otherwise proceed to Step 7.

f. Grid Map (Optional).

i. Set the TEM to the low magnification mode.

ii. Use flat edge or finder grids for mapping.

iii. Index the grid openings (fields) to be counted by marking the acceptable fields for one-half (0.5) of the area needed for analysis on each of the two grids to be analyzed. These may be marked just before examining each grid opening (field), if desired.

iv. Draw in any details which will allow the grid to be properly oriented if it is reloaded into the microscope and a particular field is to be reliably identified.

g. Scan the grid.

i. Select a field to start the examination.

ii. Choose the appropriate magnification (15,000 to 20,000X screen magnification).

iii. Scan the grid as follows.

(1) At the selected magnification, make a series of parallel traverses across the field. On reaching the end of one traverse, move the image one window and reverse the traverse.

Note: A slight overlap should be used so as not to miss any part of the grid opening (field).

(2) Make parallel traverses until the entire grid opening (field) has been scanned.

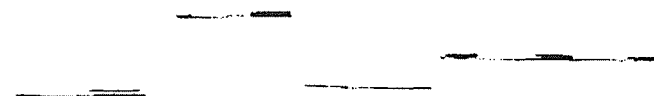
h. Identify each structure for appearance and size.

i. Appearance and size: Any continuous grouping of particles in which an asbestos fiber within aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 μm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. See the following Figure 5:

Figure 5: Asbestos Structures

Count as 1 structure: Filaments, no intersections

Count as 1 structure: Filaments, no intersections.



Count as 1 cluster if space between filaments is greater than width of 1 filament diameter or number of intersections is equal to or less than 1.



Count as 1 cluster and 1 structure if space between filaments is greater than width of 1 filament diameter or if the number of intersections is equal to or less than 1.

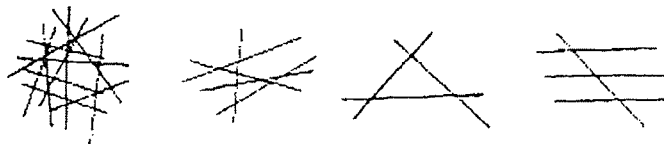


Count bundles as 1 structure: 1 or more parallel filaments less than 1 filament diameter separation.

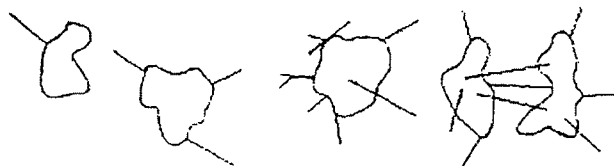


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Count clusters as 1 structure: filaments having greater than or equal to 3 intersections.

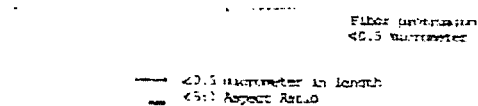


Count matrix as 1 structure.



DO NOT COUNT AS STRUCTURES:





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An intersection is a non-parallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. Combinations such as a matrix and cluster, matrix and bundle, or bundle and cluster are categorized by the dominant fiber quality -- cluster, bundle, and matrix, respectively. Separate categories will be maintained for fibers less than 5 μm and for fibers greater than or equal to 5 μm in length. Not required, but useful, may be to record the fiber length in 1 μm intervals. (Identify each structure morphologically and analyze it as it enters the "window".)

- (1) *Fiber*. A structure having a minimum length greater than 0.5 μm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed, no intersections.
- (2) *Bundle*. A structure composed of 3 or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.
- (3) *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group; groupings must have more than 2 intersections.
- (4) *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.
- (5) *NSD*. Record NSD when no structures are detected in the field.
- (6) *Intersection*. Non-parallel touching or crossing of fibers, with the projection having an aspect ratio 5:1 or greater.

ii. Structure Measurement.

- (1) Recognize the structure that is to be sized.
- (2) Memorize its location in the "window" relative to the sides, inscribed square and to other particulates in the field so this exact location can be found again when scanning is resumed.
- (3) Measure the structure using the scale on the screen.
- (4) Record the length category and structure type classification on the count sheet after the field number and fiber number.
- (5) Return the fiber to its original location in the window and scan the rest of the field for other fibers; if the direction of travel is not remembered, return to the right side of the field and begin the traverse again.

i. Visual identification of Electron Diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm² concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

i. Center the structure, focus, and obtain an ED pattern. (See Microscope Instruction Manual for more detailed instructions.)

ii. From a visual examination of the ED pattern, obtained with a short camera length, classify the observed structure as belonging to one of the following classifications: chrysotile, amphibole, or nonasbestos.

(1) Chrysotile: The chrysotile asbestos pattern has characteristic streaks on the layer lines other than the central line and some streaking also on the central line. There will be spots of normal sharpness on the central layer line and on alternate lines (2nd, 4th, etc.). The repeat distance between layer lines is 0.53 nm and the center doublet is at 0.73 nm. The pattern should display (002), (110), (130) diffraction maxima; distances and geometry should match a chrysotile pattern and be measured semiquantitatively:

(2) Amphibole Group [includes grunerite (amosite), crocidolite, anthophyllite, tremolite, and actinolite]: Amphibole asbestos fiber patterns show layer lines formed by very closely spaced dots, and the repeat distance between layer lines is also about 0.53 nm. Streaking in layer lines is occasionally present due to crystal structure defects.

(3) Nonasbestos: Incomplete or unobtainable ED patterns, a nonasbestos EDXA, or a nonasbestos morphology.

iii. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns. In the event that examination of the pattern by the qualified individual indicates that the pattern had been misidentified visually, the client shall be contacted. If the pattern is a suspected chrysotile, take a photograph of the diffraction pattern at 0 degrees tilt. If the structure is suspected to be amphibole, the sample may have to be tilted to obtain a simple geometric array of spots.

j. Energy Dispersive X-Ray Analysis (EDXA).

i. Required of all amphiboles which would cause the analysis results to exceed the 70 s/mm² concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

ii. Can be used alone to confirm chrysotile after the 70 s/mm² concentration has been exceeded.

iii. Can be used alone to confirm all nonasbestos.

iv. Compare spectrum profiles with profiles obtained from asbestos standards. The closest match identifies and categorizes the structure.

v. If the EDXA is used for confirmation, record the properly labeled spectrum on a computer disk, or if a hard copy, file with analysis data.

vi. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm² concentration, their identities must be confirmed by EDXA or measurement of a zone axis diffraction pattern to establish that the particles are nonasbestos.

k. Stopping Rules.

i. If more than 50 asbestiform structures are counted in a particular grid opening, the analysis may be terminated.

ii. After having counted 50 asbestiform structures in a minimum of 4 grid openings, the analysis may be terminated. The grid opening in which the 50th fiber was counted must be completed.

iii. For blank samples, the analysis is always continued until 10 grid openings have been analyzed.

iv. In all other samples the analysis shall be continued until an analytical sensitivity of 0.005 s/cm³ is reached.

l. Recording Rules. The count sheet should contain the following information:

i. Field (grid opening): List field number.

ii. Record "NSD" if no structures are detected.

iii. Structure information.

(1) If fibers, bundles, clusters, and/or matrices are found, list them in consecutive numerical order, starting over with each field.

(2) Length. Record length category of asbestos fibers examined. Indicate if less than 5 µm or greater than or equal to 5 µm.

(3) Structure Type. Positive identification of asbestos fibers is required by the method. At least one diffraction pattern of each fiber type from every five samples must be recorded and compared with a standard diffraction pattern. For each asbestos fiber reported, both a morphological descriptor and an identification descriptor shall be specified on the count sheet.

(4) Fibers classified as chrysotile must be identified by diffraction and/or X-ray analysis and recorded on the count sheet. X-ray analysis alone can be used as sole identification only after 70s/mm² have been exceeded for a particular sample.

(5) Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used as sole identification only after 70s/mm² have been exceeded for a particular sample.)

(6) If a diffraction pattern was recorded on film, the micrograph number must be indicated on the count sheet.

count sheet.

(7) If an electron diffraction was attempted and an appropriate spectra is not observed, N should be recorded on the count sheet.

(8) If an X-ray analysis is attempted but not observed, N should be recorded on the count sheet.

(9) If an X-ray analysis spectrum is stored, the file and disk number must be recorded on the count sheet.

m. Classification Rules.

i. *Fiber*. A structure having a minimum length greater than or equal to 0.5 μm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle*. A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

v. *NSD*. Record NSD when no structures are detected in the field.

n. After all necessary analyses of a particle structure have been completed, return the goniometer stage to 0 degrees, and return the structure to its original location by recall of the original location.

o. Continue scanning until all the structures are identified, classified and sized in the field.

p. Select additional fields (grid openings) at low magnification; scan at a chosen magnification (15,000 to 20,000X screen magnification); and analyze until the stopping rule becomes applicable.

q. Carefully record all data as they are being collected, and check for accuracy.

r. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid hold. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request. H. Sample Analytical Sequence

1. Carry out visual inspection of work site prior to air monitoring.

2. Collect a minimum of five air samples inside the work site and five samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

3. Analyze the abatement area samples according to this protocol. The analysis must meet the 0.005 s/cm³ analytical sensitivity.

4. Remaining steps in the analytical sequence are contained in Unit IV. of this Appendix. I. Reporting

The following information must be reported to the client. See the following Table II:

TABLE 11--EXAMPLE LABORATORY LETTERHEAD

[illegible]

INDIVIDUAL ANALYTICAL RESULTS

[illegible]

The analysis was carried out to the approved TEM method. This laboratory is in compliance with the quality specified by the method.

ASSIGNMENT STATEMENTS

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1. Concentration in structures per square millimeter and structures per cubic centimeter.
2. Analytical sensitivity used for the analysis.
3. Number of asbestos structures.
4. Area analyzed.
5. Volume of air samples (which was initially provided by client).
6. Average grid size opening.
7. Number of grids analyzed.
8. Copy of the count sheet must be included with the report.

9. Signature of laboratory official to indicate that the laboratory met specifications of the AHERA method.

10. Report form must contain official laboratory identification (e.g., letterhead).

11. Type of asbestos. J. Calibration Methodology

Note: Appropriate implementation of the method requires a person knowledgeable in electron diffraction and mineral identification by ED and EDXA. Those inexperienced laboratories wishing to develop capabilities may acquire necessary knowledge through analysis of appropriate standards and by following detailed methods as described in References 8 and 10 of Unit III.L.

1. *Equipment Calibration.* In this method, calibration is required for the air-sampling equipment and the transmission electron microscope (TEM).

a. *TEM Magnification.* The magnification at the fluorescent screen of the TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica. A logbook must be maintained, and the dates of calibration depend on the past history of the particular microscope; no frequency is specified. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate an eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

b. Determination of the TEM magnification on the fluorescent screen.

i. Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric).

ii. Insert a diffraction grating replica (for example a grating containing 2,160 lines/mm) into the specimen holder and place into the microscope. Orient the replica so that the grating lines fall perpendicular to the scale on the TEM fluorescent screen. Ensure that the goniometer stage tilt is 0 degrees.

iii. Adjust microscope magnification to 10,000X or 20,000X. Measure the distance (mm) between two widely separated lines on the grating replica. Note the number of spaces between the lines. Take care to measure between the same relative positions on the lines (e.g., between left edges of lines).

Note: The more spaces included in the measurement, the more accurate the final calculation. On most microscopes, however, the magnification is substantially constant only within the central 8-10 cm diameter region of the fluorescent screen.

iv. Calculate the true magnification (M) on the fluorescent screen:

$$M = \frac{2160 \times D}{S}$$

$$M = \lambda G / I$$

where:

X=total distance (mm) between the designated grating lines;

G=calibration constant of the grating replica (lines/mm);

Y=number of grating replica spaces counted along X.

c. Calibration of the EDXA System. Initially, the EDXA system must be calibrated by using two reference elements to calibrate the energy scale of the instrument. When this has been completed in accordance with the manufacturer's instructions, calibration in terms of the different types of asbestos can proceed. The EDXA detectors vary in both solid angle of detection and in window thickness. Therefore, at a particular accelerating voltage in use on the TEM, the count rate obtained from specific dimensions of fiber will vary both in absolute X-ray count rate and in the relative X-ray peak heights for different elements. Only a few minerals are relevant for asbestos abatement work, and in this procedure the calibration is specified in terms of a "fingerprint" technique. The EDXA spectra must be recorded from individual fibers of the relevant minerals, and identifications are made on the basis of semiquantitative comparisons with these reference spectra.

d. Calibration of Grid Openings.

i. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass slide and examining it under the PCM. Use a calibrated graticule to measure the average field diameter and use this number to calculate the field area for an average grid opening. Grids are to be randomly selected from batches up to 1,000.

Note: A grid opening is considered as one field.

ii. The mean grid opening area must be measured for the type of specimen grids in use. This can be accomplished on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

e. Determination of Camera Constant and ED Pattern Analysis.

i. The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film.

ii. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulates. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one half the diameter

constant using multiple gold rings can be determined. The camera constant is one-half the diameter, D, of the rings times the interplanar spacing, d, of the ring being measured. K. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Requirement
Sample receipt	Review of receiving report	Each sample	95% complete
Sample custody	Review of origin of custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Identify type or grade
	Grid recovery rate	20 repetitions/20 grids/lot or 1000 or 1 repeting/sample	100%
	Special clean area monitoring	After cleaning or service	Must meet or not up
	Laboratory blank	1 per prep series or 10%	Must meet or not up
	Plasma cell Mask	1 per 20 samples	75%
	Multiple prep (3 per sample)	Each sample	One with cover of 15 complete grid size
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or when service	95%
	ED calibration by gold standards	Weekly	95%
	EDS calibration by copper foil	Daily	95%
Performance check	Laboratory blank (measure of grid fidelity)	Prep 1 per series or 10% total 1 per 20 samples	Identify type or relative volume
	Replicate recovery (measure of precision)	1 per 100 samples	2.5 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Yearling and for comparison with unknowns	100%
	Analysis of NBS SRM 1776 and/or RM 1410 (measure of accuracy and comparability)	1 per series per year	2.5 x Poisson Std. Dev.
	Data entry review (data reduction and recovery of completeness)	Each sample	95%
	Record and verify ED electron diffraction picture of structure	1 per 10 samples	80% accuracy
Calculation and data reduction	Print calculation of automated data reduction procedure or independent recalculation of hand calculated data	1 per 100 samples	95%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks and special testing after cleaning or servicing the room.

4. Prepare multiple grids of each sample.

5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results.

If this average is greater than 55 mm \pm 2 per 10 200-mesh grid openings, check the system for possible sources of contamination.

6. Check for recovery of asbestos from cellulose ester filters submitted to plasma asher.
7. Check for asbestos carryover in the plasma asher by including a blank alongside the positive control sample.
8. Perform a systems check on the transmission electron microscope daily.
9. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III of Unit III.K.
10. Ensure qualified operator performance by evaluation of replicate counting, duplicate analysis, and standard sample comparisons as set forth in Table III of Unit III.K.
11. Validate all data entries.
12. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III.
13. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The outline of quality control procedures presented above is viewed as the minimum required to assure that quality data is produced for clearance testing of an asbestos abated area. Additional information may be gained by other control tests. Specifics on those control procedures and options available for environmental testing can be obtained by consulting References 6, 7, and 11 of Unit III.L. L. References

For additional background information on this method the following references should be consulted.

1. "Guidelines for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.
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8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc. "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters." WERL SOP 87-1, March 5, 1987.

9. NIOSH. Method 7402 for Asbestos Fibers, December 11, 1986 Draft.

10. Yamate, G., S.C. Agarwall, R.D. Gibbons, IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy." Draft report, USEPA Contract 68-02-3266, July 1984.

11. Guidance to the Preparation of Quality Assurance Project Plans. USEPA, Office of Pollution Prevention and Toxics, 1984.

IV. Mandatory Interpretation of Transmission Electron Microscopy Results to Determine Completion of Response Actions

A. Introduction

A response action is determined to be completed by TEM when the abatement area has been cleaned and the airborne asbestos concentration inside the abatement area is no higher than concentrations at locations outside the abatement area. "Outside" means outside the abatement area, but not necessarily outside the building. EPA reasons that an asbestos removal contractor cannot be expected to clean an abatement area to an airborne asbestos concentration that is lower than the concentration of air entering the abatement area from outdoors or from other parts of the building. After the abatement area has passed a thorough visual inspection, and before the outer containment barrier is removed, a minimum of five air samples inside the abatement area and a minimum of five air samples outside the abatement area must be collected. Hence, the response action is determined to be completed when the average airborne asbestos concentration measured inside the abatement area is not statistically different from the average airborne asbestos concentration measured outside the abatement area.

The inside and outside concentrations are compared by the Z-test, a statistical test that takes into account the variability in the measurement process. A minimum of five samples inside the abatement area and five samples outside the abatement area are required to control the false negative error rate, i.e., the probability of declaring the removal complete when, in fact, the air concentration inside the abatement area is significantly higher than outside the abatement area. Additional quality control is provided by requiring three blanks (filters through which no air has been drawn) to be analyzed to check for unusually high filter contamination that would distort the test results.

When volumes greater than or equal to 1,199 L for a 25 mm filter and 2,799 L for a 37 mm filter have been collected and the average number of asbestos structures on samples inside the abatement area is no greater than 70 s/mm² of filter, the response action may be considered complete without comparing the inside samples to the outside samples. EPA is permitting this initial screening test to save analysis costs in situations where the airborne asbestos concentration is sufficiently low so that it cannot be distinguished from the filter contamination/background level (fibers deposited on the filter that are unrelated to the air being sampled). The screening test cannot be used when volumes of less than 1,199 L for 25 mm filter or 2,799 L for a 37 mm filter are collected because the ability to distinguish levels significantly different from filter background is

conducted because the ability to distinguish levels significantly different from filter background is reduced at low volumes.

The initial screening test is expressed in structures per square millimeter of filter because filter background levels come from sources other than the air being sampled and cannot be meaningfully expressed as a concentration per cubic centimeter of air. The value of 70 s/mm² is based on the experience of the panel of microscopists who consider one structure in 10 grid openings (each grid opening with an area of 0.0057 mm²) to be comparable with contamination/background levels of blank filters. The decision is based, in part, on Poisson statistics which indicate that four structures must be counted on a filter before the fiber count is statistically distinguishable from the count for one structure. As more information on the performance of the method is collected, this criterion may be modified. Since different combinations of the number and size of grid openings are permitted under the TEM protocol, the criterion is expressed in structures per square millimeter of filter to be consistent across all combinations. Four structures per 10 grid openings corresponds to approximately 70 s/mm².

B. Sample Collection and Analysis

1. A minimum of 13 samples is required: five samples collected inside the abatement area, five samples collected outside the abatement area, two field blanks, and one sealed blank.

2. Sampling and TEM analysis must be done according to either the mandatory or nonmandatory protocols in Appendix A. At least 0.057 mm² of filter must be examined on blank filters.

C. Interpretation of Results

1. The response action shall be considered complete if either:

a. Each sample collected inside the abatement area consists of at least 1,199 L of air for a 25 mm filter, or 2,799 L of air for a 37 mm filter, and the arithmetic mean of their asbestos structure concentrations per square millimeter of filter is less than or equal to 70 s/mm²; or

b. The three blank samples have an arithmetic mean of the asbestos structure concentration on the blank filters that is less than or equal to 70 s/mm² and the average airborne asbestos concentration measured inside the abatement area is not statistically higher than the average airborne asbestos concentration measured outside the abatement area as determined by the Z-test. The Z-test is carried out by calculating

$$Z = \frac{\bar{Y}_I - \bar{Y}_O}{0.8(\sqrt{n_I} + \sqrt{n_O})^{1/2}}$$

where \bar{Y}_I is the average of the natural logarithms of the inside samples and \bar{Y}_O is the average of the natural logarithms of the outside samples, n_I is the number of inside samples and n_O is the number of outside samples. The response action is considered complete if Z is less than or equal to 1.65.

Note: When no fibers are counted, the calculated detection limit for that analysis is inserted for the concentration.

2. If the abatement site does not satisfy either (1) or (2) of this Section C, the site must be recleaned and a new set of samples collected.

D. Sequence for Analyzing Samples

It is possible to determine completion of the response action without analyzing all samples. Also, at any point in the process, a decision may be made to terminate the analysis of existing samples.

any point in the process, a decision may be made to terminate the analysis of existing samples, reclean the abatement site, and collect a new set of samples. The following sequence is outlined to minimize the number of analyses needed to reach a decision.

1. Analyze the inside samples.
2. If at least 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for each inside sample and the arithmetic mean concentration of structures per square millimeter of filter is less than or equal to 70 s/mm², the response action is complete and no further analysis is needed.
3. If less than 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for any of the inside samples, or the arithmetic mean concentration of structures per square millimeter of filter is greater than 70 s/mm², analyze the three blanks.
4. If the arithmetic mean concentration of structures per square millimeter on the blank filters is greater than 70 s/mm², terminate the analysis, identify and correct the source of blank contamination, and collect a new set of samples.
5. If the arithmetic mean concentration of structures per square millimeter on the blank filters is less than or equal to 70 s/mm², analyze the outside samples and perform the Z-test.
6. If the Z-statistic is less than or equal to 1.65, the response action is complete. If the Z-statistic is greater than 1.65, reclean the abatement site and collect a new set of samples.

[52 FR 41857, Oct. 30, 1987]



Appendix C

Air Sampling

EPA Guidelines SOP 2008 – General Air Sampling

Appendix C

Asbestos (bulk) by PLM
(NIOSH Method 9002, Issue 2)

ASBESTOS (bulk) by PLM

9002

various

MW: various

CAS: 1332-21-4

RTECS: C16475000

METHOD: 9002, Issue 2

EVALUATION: PARTIAL

Issue 1: 15 May 1989

Issue 2: 15 August 1994

EPA Standard (Bulk): 1%

PROPERTIES: solid, fibrous, crystalline, anisotropic

SYNONYMS [CAS #]: actinolite [77536-66-4], or ferroactinolite [15669-07-5]; amosite [12172-73-5]; anthophyllite [77536-67-5]; chrysotile [12001-29-5]; serpentine [18786-24-8]; crocidolite [12001-28-4]; tremolite [77536-68-6]; amphibole.

SAMPLING		MEASUREMENT	
BULK SAMPLE:	1 to 10 grams	TECHNIQUE:	MICROSCOPY, STEREO AND POLARIZED LIGHT, WITH DISPERSION STAINING
SHIPMENT:	seal securely to prevent escape of asbestos	ANALYTE:	actinolite asbestos, amosite, anthophyllite asbestos, chrysotile, crocidolite, tremolite asbestos
SAMPLE STABILITY:	stable	EQUIPMENT:	microscope, polarized light; 100-400X dispersion staining objective, stereo microscope: 10-45X
BLANKS:	none required	RANGE:	1% to 100% asbestos
ACCURACY		ESTIMATED LOD:	<1% asbestos [1]
RANGE STUDIED:	<1% to 100% asbestos	PRECISION:	not determined
BIAS:	not determined		
PRECISION:	not determined		
ACCURACY:	not determined		

APPLICABILITY: this method is useful for the qualitative identification of asbestos and the semi-quantitative determination of asbestos content of bulk samples. The method measures percent asbestos as perceived by the analyst in comparison to standard area projections, photos, and drawings, or trained experience. The method is not applicable to samples containing large amounts of fine fibers below the resolution of the light microscope

INTERFERENCES: Other fibers with optical properties similar to the asbestos minerals may give positive interferences. Optical properties of asbestos may be obscured by coating on the fibers. Fibers finer than the resolving power of the microscope (ca. 0.3 µm) will not be detected. Heat and acid treatment may alter the index of refraction of asbestos and change its color.

OTHER METHODS: This method (originally designated as method 7403) is designed for use with NIOSH Methods 7400 (phase contrast microscopy) and 7402 (electron microscopy/EDS). The method is similar to the EPA bulk asbestos method [1].

REAGENTS:

1. Refractive index (RI) liquids for Dispersion Staining: high-dispersion (HD) series, 1.550, 1.605, 1.620.
2. Refractive index liquids: 1.670, 1.680, and 1.700.
3. Asbestos reference samples such as SRM #1866, available from the National Institute of Standards and Technology.*
4. Distilled Water (optional).
5. Concentrated HCl: ACS reagent grade.

* See SPECIAL PRECAUTIONS

EQUIPMENT:

1. Sample containers: screw-top plastic vials of 10- to 50-mL capacity.
2. Microscope, polarized light, with polarizer, analyzer, port for retardation plate, 360° graduated rotating stage, substage condenser with iris, lamp, lamp iris, and:
 - a. Objective lenses: 10X, 20X, and 40X or near equivalent.
 - b. Ocular lense: 10X minimum.
 - c. Eyepiece reticle: crosshair.
 - d. Dispersion staining objective lens or equivalent.
 - e. Compensator plate: ca. 550 nm± 20 nm, retardation: "first order red" compensator.
3. Microscope slides: 75 mm x 25 mm.
4. Cover slips.
5. Ventilated hood or negative-pressure glove box.
6. Mortar and pestle: agate or porcelain.
7. Stereomicroscope, ca. 10 to 45X.
8. Light source: incandescent or fluorescent.
9. Tweezers, dissecting needles, spatulas, probes, and scalpels.
10. Glassine paper or clean glass plate.
11. Low-speed hand drill with coarse burr bit (optional).

SPECIAL PRECAUTIONS: Asbestos, a human carcinogen, should be handled only in an exhaust hood (equipped with a HEPA filter) [2]. Precautions should be taken when collecting unknown samples, which may be asbestos, to preclude exposure to the person collecting the sample and minimize the disruption to the parent material [3]. Disposal of asbestos-containing materials should follow EPA Guidelines [4].

SAMPLING:

1. Place 1 to 10 g of the material to be analyzed in a sample container.
NOTE: For large samples (i.e., whole ceiling tiles) that are fairly homogenous, a representative small portion should be submitted for analysis. Sample size should be adjusted to ensure that it is representative of the parent material.
2. Make sure that sample containers are taped so they will not open in transit.
3. Ship the samples in a rigid container with sufficient packing material to prevent damage or sample loss.

SAMPLE PREPARATION:

4. Visually examine samples in the container and with a low-magnification stereomicroscope in a hood. (If necessary, a sample may be carefully removed from the container and placed on glassine transfer paper or clean glass plate for examination). Break off a portion of the sample and examine the edges for emergent fibers. Note the homogeneity of the sample. Some hard tiles can be broken, and the edges examined for emergent fibers. If fibers are found, make an estimate of the amount and type of fibers present, confirm fiber type (step 14) and quantify (step 15).
5. In a hood, open sample container and with tweezers remove small, representative portions of the sample.
 1. If there are obvious separable layers, sample and analyze each layer separately.

- b. If the sample appears to be slightly inhomogeneous, mix it in the sample container with tweezers or a spatula before taking the portion of analysis. Alternatively, take small representative portions of each type of material and place on a glass slide.
 - c. On hard tiles that may have thin, inseparable layers, use a scalpel to cut through all the layers for a representative sample. Then cut it into smaller pieces after placing RI liquid on it before trying to reduce the thickness. Alternatively, use a low-speed hand drill equipped with a burr bit to remove material from hard tiles. Avoid excessive heating of the sample which may alter the optical properties of the material.
NOTE: This type of sample often requires ashing or other specialized preparation, and may require transmission electron microscopy for detection of the short asbestos fibers which are characteristic of floor tiles.
 - d. If the sample has large, hard particles, grind it in a mortar. Do not grind so fine that fiber characteristics are destroyed.
 - e. If necessary, treat a portion of the sample in a hood with an appropriate solvent to remove binders, tars, and other interfering materials which may be present in the sample. Make corrections for the non-asbestos material removed by this process.
NOTE: Other methods of sample preparation such as acid washing and sodium metaphosphate treatment and ashing may be necessary, especially to detect low concentrations of asbestos. If needed, use as described in Reference [1].
6. After placing a few drops of RI liquid on the slide, put a small portion of sample in the liquid. Tease apart with a needle or smash small clumps with the flat end of a spatula or probe, producing a uniform thickness or particles so that better estimates of projected area percentages can be made. Mix the fibers and particles on the slide so that they are as homogeneous as possible.
NOTE: An even dispersion of sample should cover the entire area under the cover slip. Some practice will be necessary to judge the right amount of material to place on the slide. Too little sample may not give sufficient information and too much sample cannot be easily analyzed.

CALIBRATION AND QUALITY CONTROL:

7. Check for contamination each day of operation. Wipe microscope slides and cover slips with lens paper before using. Check refractive index liquids. Record results in a separate logbook.
8. Verify the refractive indices of the refractive index liquids used once per week of operation. Record these checks in a separate logbook.
9. Follow the manufacturer's instructions for illumination, condenser alignment and other microscope adjustments. Perform these adjustments prior to each sample set.
10. Determine percent of each identified asbestos species by comparison to standard projections (Figure 1) [1]. If no fibers are detected in a homogeneous sample, examine at least two additional preparations before concluding that no asbestos is present.
11. If it appears that the preparation technique might not be able to produce a homogeneous or representative sample on the slide, prepare a duplicate slide and average the results. Occasionally, when the duplicate results vary greatly, it will be necessary to prepare additional replicate slides and average all the replicate results. Prepare duplicate slides of at least 10% of the samples analyzed. Average the results for reporting.
12. Analyze about 5% blind samples of known asbestos content.
13. Laboratories performing this analytical method should participate in the National Voluntary Laboratory Accreditation Program [5] or a similar interlaboratory quality control program. Each analyst should have complete formal training in polarized light microscopy and its application to crystalline materials. In lieu of formal training, laboratory training in asbestos bulk analysis under the direction of a trained asbestos bulk analyst may be substituted. Owing to the subjective nature of the method, frequent practice is essential in order to remain proficient in estimating projected area percentages.

QUALITATIVE ASSESSMENT:

14. Scan the slide to identify any asbestos minerals using the optical properties of morphology,

refractive indices, color, pleochroism, birefringence, extinction characteristics, sign of elongation, and dispersion staining characteristics.

NOTE: Identification of asbestos using polarized light microscopy is unlike most other analytical methods. The quality of the results is dependent on the skill and judgment of the analyst. This method does not lend itself easily to a step-wise approach. Various procedures devised by different analysts may yield equivalent results. The following step-wise procedure repeatedly utilizes the sample preparation procedure previously outlined.

- a. Prepare a slide using 1.550 HD RI liquid. Adjust the polarizing filter such that the polars are partially crossed, with ca. 15° offset. Scan the preparation, examining the morphology for the presence of fibers. If no fibers are found, scan the additional preparations. If no fibers are found in any of the preparations, report that the sample does not contain asbestos, and stop the analysis at this point.
- b. If fibers are found, adjust the polarizing filter such that the polars are fully crossed. If all of the fibers are isotropic (disappear at all angles of rotation) then those fibers are not asbestos. Fibrous glass and mineral wool, which are common components of suspect samples, are isotropic. If only isotropic fibers are found in the additional preparations, report no asbestos fibers detected, and stop the analysis.
- c. If anisotropic fibers are found, rotate the stage to determine the angle of extinction. Except for tremolite-actinolite asbestos which has oblique extinction at 10-20°, the other forms of asbestos exhibit parallel extinction (Table 1). Tremolite may show both parallel and oblique extinction.
- d. Insert the first order red compensator plate in the microscope and determine the sign of elongation. All forms of asbestos have a positive sign of elongation except for crocidolite. If the sign of elongation observed is negative, go to step "g."

NOTE: To determine the direction of the sign of elongation on a particular microscope configuration, examine a known chrysotile sample and note the direction (NE-SW or NW-SE) of the blue coloration. Chrysotile has a positive sign of elongation.

- e. Remove the first-order red compensator and uncross the polarizer. Examine under plane polarized light for blue and gold-brown Becke colors at the fiber-oil interface (i.e., index of refraction match). Becke colors are not always evident. Examine fiber morphology for twisted, wavy bundles of fibers which are characteristic of chrysotile. Twisted, ribbon-like morphology with cellular internal features may indicate cellulose fibers. It may be necessary to cross the polars partially in order to see the fibers if the index of refraction is an exact match at 1.550. If the fibers appear to have higher index of refraction, go to step "h," otherwise continue.
- f. Identification of chrysotile. Insert the dispersion staining objective. Observation of dispersion staining colors of blue and blue-magenta confirms chrysotile. Cellulose, which is a common interfering fiber at the 1.550 index of refraction, will not exhibit these dispersion staining colors. If chrysotile is found, go to step 15 for quantitative estimation.
- g. Identification of crocidolite. Prepare a slide in 1.700 RI liquid. Examine under plane-polarized light (uncrossed polars); check for morphology of crocidolite. Fibers will be straight, with rigid appearance, and may appear blue or purple-blue. Crocidolite is pleochroic, i.e., it will appear to change its color (blue or gray) as it is rotated through plane polarized light. Insert the dispersion staining objective. The central stop dispersion staining color are red magenta and blue magenta, however, these colors are sometimes difficult to impossible to see because of the opacity of the dark blue fibers. If observations above indicate crocidolite, go to step 15 for quantitative estimation.
- h. Identification of amosite. Prepare a slide in 1.680 RI liquid. Observed the fiber morphology for amosite characteristics: straight fibers and fiber bundles with broom-like or splayed ends. If the morphology matches amosite, examine the fibers using the dispersion staining objective. Blue and pale blue colors indicate the cummingtonite form of amosite, and gold and blue colors indicate the grunerite form of amosite. If amosite is confirmed by this test, go to step 15 for quantitative estimation, otherwise continue.
- i. Identification of anthophyllite-tremolite-actinolite. Prepare a slide in 1.605 HD RI liquid. Examine morphology for comparison to anthophyllite-tremolite-actinolite asbestos. The refractive indices for these forms of asbestos vary naturally within the species. Anthophyllite can be distinguished from actinolite and tremolite by its nearly parallel extinction. Actinolite has a light to dark green color under plane-polarized light and exhibits some pleochroism. For all

three, fibers will be straight, single fibers possibly with some larger composite fibers. Cleavage fragments may also be present. Examine using the central stop dispersion staining objective. Anthophyllite will exhibit central stop colors of blue and gold/gold-magenta; tremolite will exhibit pale blue and yellow; and actinolite will exhibit magenta and golden-yellow colors.

NOTE: In this refractive index range, wollastonite is a common interfering mineral with similar morphology including the presence of cleavage fragments. It has both positive and negative sign of elongation, parallel extinction, and central stop dispersion staining colors of pale yellow and pale yellow to magenta. If further confirmation of wollastonite versus anthophyllite is needed, go to step "j". If any of the above forms of asbestos were confirmed above, go to step 15 for quantitative estimation. If none of the tests above confirmed asbestos fibers, examine the additional preparations and if the same result occurs, report the absence of asbestos in this sample.

- j. Wash a small portion of the sample in a drop of concentrated hydrochloric acid on a slide. Place the slide, with cover slip in place, on a warm hot plate until dry. By capillary action, place 1.620 RI liquid under the cover clip and examine the slide. Wollastonite fibers will have a "cross-hatched" appearance across the length of the fibers and will not show central stop dispersion colors. Anthophyllite and tremolite will still show their original dispersion colors.

NOTE: There are alternative analysis procedures to the step-wise approach outlined above which will yield equivalent results. Some of these alternatives are:

- i. Perform the initial scan for the presence of asbestos using crossed polars as well as the first-order red compensator. This allows for simultaneous viewing of birefringent and amorphous materials as well as determine their sign of elongation. Some fibers which are covered with mortar may best be observed using this configuration.
- ii. Some analysts prefer to mount their first preparation in a RI liquid different than any asbestos materials and conduct their initial examination under plane-polarized light.
- iii. If alternative RI liquids are used from those specified, dispersion staining colors observed will also change. Refer to an appropriate reference for the specific colors associated with asbestos in the RI liquids actually used.

QUANTITATIVE ASSESSMENT:

15. Estimate the content of the asbestos type present in the sample using the 1.550 RI preparation.

Express the estimate as an area percent of all material present, taking into account the loading and distribution of all sample material on the slide. Use Figure 1 as an aid in arriving at your estimate. If additional unidentified fibers are present in the sample, continue with the qualitative measurement (step 14).

NOTE: Point-counting techniques to determine percentages of the asbestos minerals are not generally recommended. The point-counting method only produces accurate quantitative data when the material on the slide is homogeneous and has a uniform thickness, which is difficult to obtain [6]. The point-counting technique is, recommended by the EPA to determine the amount of asbestos in bulk [1]; however, in the more recent Asbestos Hazard Emergency Response Act (AHERA) regulations, asbestos quantification may be performed by a point-counting or equivalent estimation method [7].

16. Make a quantitative estimate of the asbestos content of the sample from the appropriate combination of the estimates from both the gross and microscopic examinations. If asbestos fibers are identified, report the material as "asbestos-containing". Asbestos content should be reported as a range of percent content. The range reported should be indicative of the analyst's precision in estimating asbestos content. For greater quantities use Figure 1 in arriving at your estimate.

EVALUATION OF METHOD:

The method is compiled from standard techniques used in mineralogy [8-13], and from standard laboratory procedures for bulk asbestos analysis which have been utilized for several years. These

techniques have been successfully applied to the analysis of EPA Bulk Sample Analysis Quality Assurance Program samples since 1982 [1,5]. However, no formal evaluation of this method, as written, has been performed.

REFERENCES:

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METHOD WRITTEN BY:

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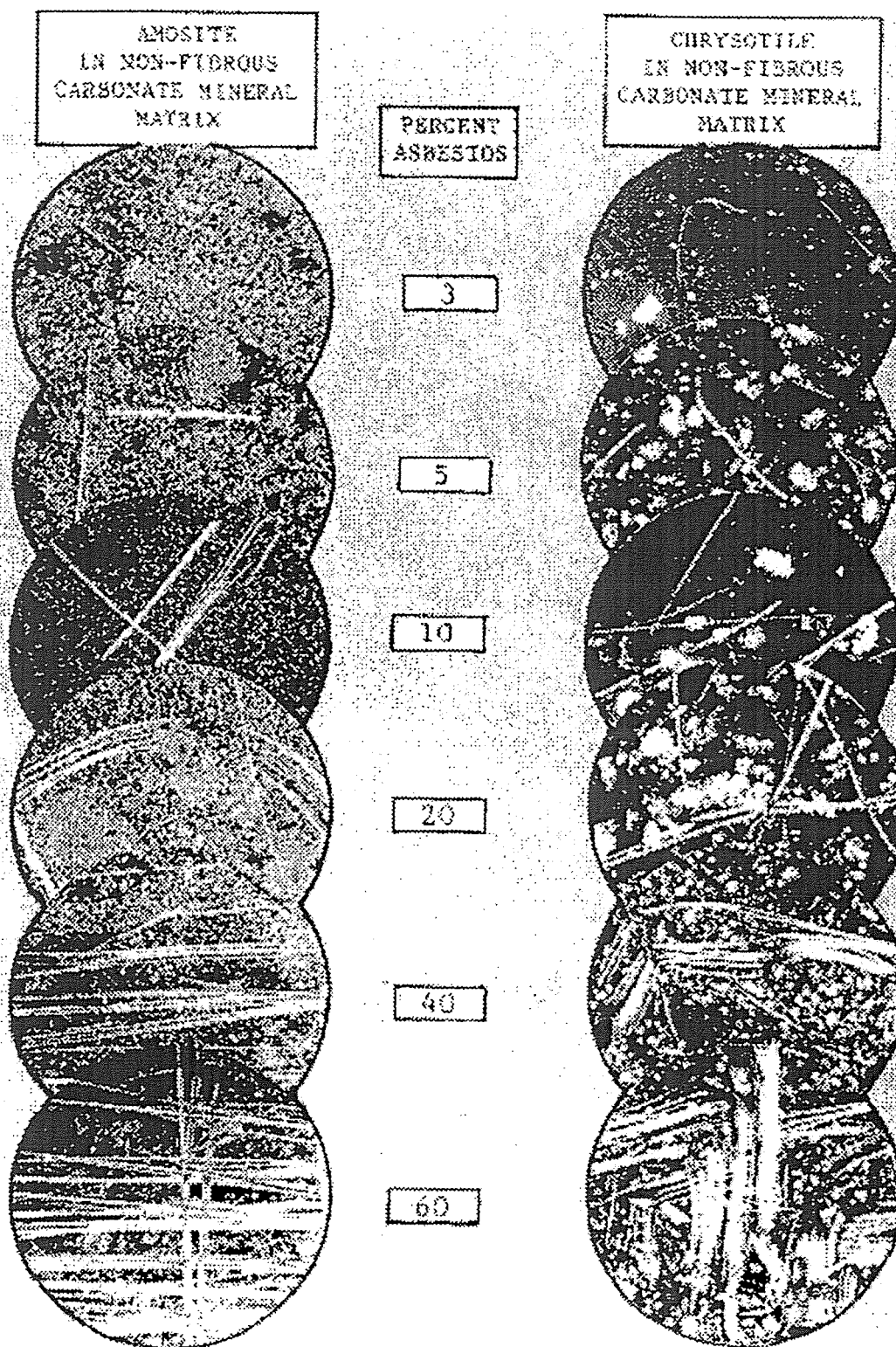


Figure 1. Percent estimate comparator

Table 1. Optical Properties of Asbestos Fibers				
Mineral	Morphology and Color	Refractive Index (Approximate Values)		Birefringence
		\perp to Elongation	\parallel to Elongation	
Chrysotile	Wavy fibers with kinks. Splayed ends on larger bundles. Colorless to light brown upon being heated. Nonpleochroic. Aspect ratio typically >10:1.	1.54	1.55	0.002 - 0.014
Cummingtonite- Grunerite (Amosite)	Straight fibers and fiber bundles. Bundle ends appear broom-like or splayed. Colorless to brown upon heating. May be weakly pleochroic. Aspect ratio typically >10:1.	1.67	1.70	0.02 - 0.03
Crocidolite (Riebeckite)	Straight fibers and fiber bundles. Longer fibers show curvature. Splayed ends on bundles. Characteristic blue color. Pleochroic. Aspect ratio typically >10:1.	1.71	1.70	0.014 - 0.016 Interference colors may be masked by blue color.
Anthophyllite	Straight fibers and fiber bundles. Cleavage fragments may be present. Colorless to light brown. Nonpleochroic to weakly pleochroic. Aspect ratio generally <10:1.	1.61	1.63	0.019 - 0.024
Tremolite- Actinolite	Straight and curved fibers. Cleavage fragments common. Large fiber bundles show splayed ends. Tremolite is colorless. Actinolite is green and weakly to moderately pleochroic. Aspect ratio generally <10:1.	1.60 - 1.62 (tremolite) 1.62 - 1.67 (actinolite)	1.62 - 1.64 (tremolite) 1.64 - 1.68 (actinolite)	0.02 - 0.03

Table 1. Optical Properties of Asbestos Fibers (Continued)					
Mineral	Extinction	Sign of Elongation	Central Stop Dispersion Staining Colors		
			RI Liquid	\perp to Vibration	\parallel to Vibration
Chrysotile	Parallel to fiber length	+ (length slow)	1.550 ^{HD}	Blue	Blue-magenta
Cummingtonite-Grunerite (Amosite)	Parallel to fiber length	+ (length slow)	1.670 Fibers subjected to high temperatures will not dispersion-stain. 1.680 1.680	Red magenta to blue pale blue blue	Yellow blue gold
Crocidolite (Riebeckite)	Parallel to fiber length	- (length fast)	1.700 1.680	Red magenta yellow	Blue-magenta pale yellow
Anthophyllite	Parallel to fiber length	+ (length slow)	1.605 ^{HD} 1.620 ^{HD}	Blue Blue-green	Gold to gold-magenta Golden-yellow
Tremolite-Actinolite	Oblique - 10 to 20° for fragments. Some composite fibers show \parallel extinction.	+ (length slow)	1.605 ^{HD}	Pale blue (tremolite) Yellow (actinolite)	Yellow (tremolite) Pale yellow (actinolite)
HD = high-dispersion RI liquid series.					

Appendix D

Asbestos Sampling
(EPA SOP 2015, Revision 0.0)



ASBESTOS SAMPLING

SOP#: 2015
DATE: 11/17/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

Asbestos has been used in many commercial products including building materials such as flooring tiles and sheet goods, paints and coatings, insulation, and roofing asphalts. These products and others may be found at hazardous waste sites hanging on overhead pipes, contained in drums, abandoned in piles, or as part of a structure. Asbestos tailing piles from mining operations can also be a source of ambient asbestos fibers. Asbestos is a known carcinogen and requires air sampling to assess airborne exposure to human health. This Standard Operating Procedure (SOP) provides procedures for asbestos air sampling by drawing a known volume of air through a mixed cellulose ester (MCE) filter. The filter is then sent to a laboratory for analysis. The U.S. Environmental Protection Agency/Environmental Response Team (U.S. EPA/ERT) uses one of four analytical methods for determining asbestos in air. These include: U.S. EPA's Environmental Asbestos Assessment Manual, Superfund Method for the Determination of Asbestos in Ambient Air for Transmission Electron Microscopy (TEM)⁽¹⁾; U.S. EPA's Modified Yamate Method for TEM⁽²⁾; National Institute for Occupational Safety and Health (NIOSH) Method 7402 (direct method only) for TEM; and NIOSH Method 7400 for Phase Contrast Microscopy (PCM)⁽³⁾. Each method has specific sampling and analytical requirements (i.e., sample volume and flow rate) for determining asbestos in air.

The U.S. EPA/ERT typically follows procedures outlined in the TEM methods for determining mineralogical types of asbestos in air and for distinguishing asbestos from non-asbestos minerals. The Phase Contrast Microscopy (PCM) method is used by U.S. EPA/ERT as a screening tool since it is less costly than TEM. PCM cannot distinguish asbestos from non-asbestos fibers, therefore the TEM method may be necessary to confirm analytical results. For example, if an action level for the presence of fibers has been set and PCM analysis indicates that the action level has been exceeded, then

TEM analysis can be used to quantify and identify asbestos structures through examination of their morphology crystal structures (through electron diffraction), and elemental composition (through energy dispersive X-ray analysis). In this instance samples should be collected for both analyses in side by side sampling trains (some laboratories are able to perform PCM and TEM analysis from the same filter). The Superfund method is designed specifically to provide results suitable for supporting risk assessments at Superfund sites, it is applicable to a wide range of ambient air situations at hazardous waste sites. U.S. EPA's Modified Yamate Method for TEM is also used for ambient air sampling due to high volume requirements. The PCM and TEM NIOSH analytical methods require lower sample volumes and are typically used indoors; however, ERT will increase the volume requirement for outdoor application.

Other Regulations pertaining to asbestos have been promulgated by U.S. EPA and OSHA. U.S. EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) regulates asbestos-containing waste materials. NESHAP establishes management practices and standards for the handling of asbestos and emissions from waste disposal operations (40 CFR Part 61, Subparts A and M). U.S. EPA's 40 CFR 763 (July 1, 1987)⁽⁴⁾ and its addendum 40 CFR 763 (October 30, 1987)⁽⁴⁾ provide comprehensive rules for the asbestos abatement industry. State and local regulations on these issues vary and may be more stringent than federal requirements. The OSHA regulations in 29 CFR 1910.1001 and 29 CFR 1926.58 specify work practices and safety equipment such as respiratory protection and protective clothing when handling asbestos. The OSHA standard for an 8-hour, time-weighted average (TWA) is 0.2 fibers/cubic centimeters of air. This standard pertains to fibers with a length-to-width ratio of 3 to 1 with a fiber length $>5 \mu\text{m}$ ^(5,6). An action level of 0.1 fiber/cc (one-half the OSHA standard) is the level U.S. EPA has established in which employers must initiate such activities as air monitoring, employee training, and

medical surveillance^{5,6}.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Prior to sampling, the site should be characterized by identifying on-site as well as off-site sources of airborne asbestos. The array of sampling locations and the schedule for sample collection, is critical to the success of an investigation. Generally, sampling strategies to characterize a single point source are fairly straightforward, while multiple point sources and area sources increase the complexity of the sampling strategy. It is not within the scope of this SOP to provide a generic asbestos air sampling plan. Experience, objectives, and site characteristics will dictate the sampling strategy.

During a site investigation, sampling stations should be arranged to distinguish spatial trends in airborne asbestos concentrations. Sampling schedules should be fashioned to establish temporal trends. The sampling strategy typically requires that the concentration of asbestos at the source (worst case) or area of concern (downwind), crosswind, as well as background (upwind) contributions be quantified. See Table 1 (Appendix A) for U.S. EPA/ERT recommended sampling set up for ambient air. Indoor asbestos sampling requires a different type of strategy which is identified in Table 2 (Appendix A). It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks can be utilized to determine other sources.

Much information can be derived from each analytical method previously mentioned. Each analytical method has specific sampling requirements and produce results which may or may not be applicable to a specific sampling effort. The site sampling

objectives should be carefully identified so as to select the most appropriate analytical method. Additionally, some preparation (i.e., lot blanks results) prior to site sampling may be required, these requirements are specified in the analytical methods.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Sample Preservation

No preservation is required for asbestos samples.

3.2 Sample Handling, Container and Storage Procedures

1. Place a sample label on the cassette indicating a unique sampling number. Do not put sampling cassettes in shirt or coat pockets as the filter can pick up fibers. The original cassette box is used to hold the samples.
2. Wrap the cassette individually in a plastic sample bag. Each bag should be marked indicating sample identification number, total volume, and date.
3. The wrapped sampling cassettes should be placed upright in a rigid container so that the cassette cap is on top and cassette base is on bottom. Use enough packing material to prevent jostling or damage. Do not use vermiculite as packing material for samples. If possible, hand carry to lab.
4. Provide appropriate documentation with samples (i.e., chain of custody and requested analytical methodology).

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Flow rates exceeding 16 liters/minute (L/min) which could result in filter destruction due to (a) failure of its physical support under force from the increased pressure drop; (b) leakage of air around the filter mount so that the filter is bypassed, or (c) damage to the asbestos structures due to increased impact velocities.

4.1 U.S. EPA's Superfund Method

4.1.1 Direct-transfer TEM Specimen Preparation Methods

Direct-Transfer TEM specimen preparation methods have the following significant interferences:

- The achievable detection limit is restricted by the particulate density on the filter, which in turn is controlled by the sampled air volume and the total suspended particulate concentration in the atmosphere being sampled.
- The precision of the result is dependent on the uniformity of the deposit of asbestos structures on the sample collection filter.
- Air samples must be collected so that they have particulate and fiber loadings within narrow ranges. If too high a particulate loading occurs on the filter, it is not possible to prepare satisfactory TEM specimens by a direct-transfer method. If too high a fiber loading occurs on the filter, even if satisfactory TEM specimens can be prepared, accurate fiber counting will not be possible.

4.1.2 Indirect TEM Specimen Preparation Methods

Indirect TEM specimen preparation methods have the following interferences:

- The size distribution of asbestos structures is modified.
- There is increased opportunity for fiber loss or introduction of extraneous contamination.
- When sample collection filters are ashed, any fiber contamination in the filter medium is concentrated on the TEM specimen grid.

It can be argued that direct methods yield an under-estimate of the asbestos structure concentration because many of the asbestos fibers present are concealed by other particulate material with which they are associated. Conversely, indirect methods can be considered to yield an over-estimate because some types of complex asbestos structures disintegrate

during the preparation, resulting in an increase in the numbers of structures counted.

4.2 U.S. EPA's Modified Yamate Method for TEM

High concentrations of background dust interfere with fiber identification.

4.3 NIOSH Method for TEM

Other amphibole particles that have aspect ratios greater than 3:1 and elemental compositions similar to the asbestos minerals may interfere in the TEM analysis. Some non-amphibole minerals may give electron diffraction patterns similar to amphiboles. High concentrations of background dust interfere with fiber identification.

4.4 NIOSH Method for PCM

PCM cannot distinguish asbestos from non-asbestos fibers; therefore, all particles meeting the counting criteria are counted as total asbestos fibers. Fiber less than 0.25 μm in length will not be detected by this method. High levels of non-fibrous dust particles may obscure fibers in the field of view and increase the detection limit.

5.0 EQUIPMENT/MATERIALS

5.1 Sampling Pump

The constant flow or critical orifice controlled sampling pump should be capable of a flow-rate and pumping time sufficient to achieve the desired volume of air sampled.

The lower flow personal sampling pumps generally provide a flow rate of 20 cubic centimeters/minute (cc/min) to 4 L/min. These pumps are usually battery powered. High flow pumps are utilized when flow rates between 2 L/min to 20 L/min are required. High flow pumps are used for short sampling periods so as to obtain the desired sample volume. High flow pumps usually run on AC power and can be plugged into a nearby outlet. If an outlet is not available then a generator should be obtained. The generator should be positioned downwind from the sampling pump. Additional voltage may be required if more than one pump is plugged into the same generator. Several

electrical extension cords may be required if sampling locations are remote.

The recommended volume for the Superfund method (Phase I) requires approximately 20 hours to collect. Such pumps typically draw 6 amps at full power so that 2 lead/acid batteries should provide sufficient power to collect a full sample. The use of line voltage, where available, eliminates the difficulties associated with transporting stored electrical energy.

A stand should be used to hold the filter cassette at the desired height for sampling and the filter cassette shall be isolated from the vibrations of the pump.

5.2 Filter Cassette

The cassettes are purchased with the required filters in position, or can be assembled in a laminar flow hood or clean area. When the filters are in position, a shrink cellulose band or adhesive tape should be applied to cassette joints to prevent air leakage.

5.2.1 TEM Cassette Requirements

Commercially available field monitors, comprising 25 mm diameter three-piece cassettes, with conductive extension cowls shall be used for sample collection. The cassette must be new and not previously used. The cassette shall be loaded with an MCE filter of pore size 0.45 μm , and supplied from a lot number which has been qualified as low background for asbestos determination. The cowls should be constructed of electrically conducting material to minimize electrostatic effects. The filter shall be backed by a 5 μm pore size MCE filter (Figure 1, Appendix B).

5.2.2 PCM Cassette Requirements

NIOSH Method 7400, PCM involves using a 0.8 to 1.2 μm mixed cellulose ester membrane, 25 mm diameter, 50 mm conductive cowl on cassette (Figure 2, Appendix B). Some labs are able to perform PCM and TEM analysis on the same filter; however, this should be discussed with the laboratory prior to sampling.

5.3 Other Equipment

- Inert tubing with glass cyclone and hose barb
- Whirlbags (plastic bags) for cassettes

- Tools - small screw drivers
- Container - to keep samples upright
- Generator or electrical outlet (may not be required)
- Extension cords (may not be required)
- Multiple plug outlet
- Sample labels
- Air data sheets
- Chain of Custody records

6.0 REAGENTS

Reagents are not required for the preservation of asbestos samples.

7.0 PROCEDURES

7.1 Air Volumes and Flow Rates

Sampling volumes are determined on the basis of how many fibers need to be collected for reliable measurements. Therefore, one must estimate how many airborne fibers may be in the sampling location.

Since the concentration of airborne aerosol contaminants will have some effect on the sample, the following is a suggested criteria to assist in selecting a flow rate based on real-time aerosol monitor (RAM) readings in milligrams/cubic meter (mg/m^3).

	<u>Concentration</u>	<u>Flow Rate</u>
• Low RAM readings:	<6.0 mg/m^3	11-15 L/min
• Medium RAM readings:	>6.0 mg/m^3	7.5 L/min
• High RAM readings:	>10 mg/m^3	2.5 L/min

In practice, pumps that are available for environmental sampling at remote locations operate under a maximum load of approximately 12 L/min.

7.1.1 U.S. EPA's Superfund Method

The Superfund Method incorporates an indirect preparation procedure to provide flexibility in the amount of deposit that can be tolerated on the sample filter and to allow for the selective concentration of asbestos prior to analysis. To minimize contributions to background contamination from asbestos present in the plastic matrices of membrane filters while allowing for sufficient quantities of asbestos to be collected, this method also requires the collection of a larger volume of air per unit area of filter than has traditionally been collected

for asbestos analysis. Due to the need to collect large volumes of air, higher sampling flow rates are recommended in this method than have generally been employed for asbestos sampling in the past. As an alternative, samples may be collected over longer time intervals. However, this restricts the flexibility required to allow samples to be collected while uniform meteorological conditions prevail.

The sampling rate and the period of sampling should be selected to yield as high a sampled volume as possible, which will minimize the influence of filter contamination. Wherever possible, a volume of 15 cubic meters (15,000 L) shall be sampled for those samples intended for analysis only by the indirect TEM preparation method (Phase 1 samples). For those samples to be prepared by both the indirect and the direct specimen preparation methods (Phase 2 samples), the volumes must be adjusted so as to provide a suitably-loaded filter for the direct TEM preparation method. One option is to collect filters at several loadings to bracket the estimated optimum loading for a particular site. Such filters can be screened in the laboratory so that only those filters closest to optimal loading are analyzed. It has been found that the volume cannot normally exceed 5 cubic meters (5000 L) in an urban or agricultural area, and 10 cubic meters (10,000 L) in a rural area for samples collected on a 25 mm filter and prepared by a direct-transfer technique.

An upper limit to the range of acceptable flow rates for this method is 15 L/min. At many locations, wind patterns exhibit strong diurnal variations. Therefore, intermittent sampling (sampling over a fixed time interval repeated over several days) may be necessary to accumulate 20 hours of sampling time over constant wind conditions. Other sampling objectives also may necessitate intermittent sampling. The objective is to design a sampling schedule so that samples are collected under uniform conditions throughout the sampling interval. This method provides for such options. Air volumes collected on Phase 1 samples are maximized (<16 L/min). Air volumes collected on Phase 2 samples are limited to provide optimum loading for filters to be prepared by a direct-transfer procedure.

7.1.2 U.S. EPA's Modified Yamate Method for TEM

U.S. EPA's TEM method requires a minimum volume

of 560 L and a maximum volume of 3,800 L in order to obtain an analytical sensitivity of 0.005 structures/cc. The optimal volume for TEM is 1200 L to 1800 L. These volumes are determined using a 200 mesh EM grid opening with a 25-mm filter cassette. Changes in volume would be necessary if a 37-mm filter cassette is used since the effective area of a 25 mm (385 sq mm) and 37 mm (855 sq mm) differ.

7.1.3 NIOSH Method for TEM and PCM

The minimum recommended volume for TEM and PCM is 400 L at 0.1 fiber/cc. Sampling time is adjusted to obtain optimum fiber loading on the filter. A sampling rate of 1 to 4 L/min for eight hours (700 to 2800 L) is appropriate in non-dusty atmospheres containing 0.1 fiber/cc. Dusty atmospheres i.e., areas with high levels of asbestos, require smaller sample volumes (<400 L) to obtain countable samples.

In such cases, take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high flow rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3,000 to 10,000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust. If > 50% of the filter surface is covered with particles, the filter may be too overloaded to count and will bias the measured fiber concentration. Do not exceed 0.5 mg total dust loading on the filter.

7.2 Calibration Procedures

In order to determine if a sampling pump is measuring the flow rate or volume of air correctly, it is necessary to calibrate the instrument. Sampling pumps should be calibrated immediately before and after each use. Preliminary calibration should be conducted using a primary calibrator such as a soap bubble type calibrator, (e.g., a Buck Calibrator, Gilibrator, or equivalent primary calibrator) with a representative filter cassette installed between the pump and the calibrator. The representative sampling cassette can be reused for calibrating other pumps that will be used for asbestos sampling. The same cassette lot used for sampling should also be used for the calibration. A sticker should be affixed to the outside of the extension cowl marked "Calibration Cassette."

A rotameter can be used provided it has been recently precalibrated with a primary calibrator. Three separate constant flow calibration readings should be obtained both before sampling and after sampling. Should the flow rate change by more than 5% during the sampling period, the average of the pre- and post-calibration rates will be used to calculate the total sample volume. The sampling pump used shall provide a non-fluctuating air-flow through the filter, and shall maintain the initial volume flow-rate to within $\pm 10\%$ throughout the sampling period. The mean value of these flow-rate measurements shall be used to calculate the total air volume sampled. A constant flow or critical orifice controlled pump meets these requirements. If at any time the measurement indicates that the flow-rate has decreased by more than 30%, the sampling shall be terminated. Flexible tubing is used to connect the filter cassette to the sampling pump. Sampling pumps can be calibrated prior to coming on-site so that time is saved when performing on-site calibration.

7.2.1 Calibrating a Personal Sampling Pump with an Electronic Calibrator

1. See Manufacturer's manual for operational instructions.
2. Set up the calibration train as shown in (Figure 3, Appendix B) using a sampling pump, electronic calibrator, and a representative filter cassette. The same lot sampling cassette used for sampling should also be used for calibrating.
3. To set up the calibration train, attach one end of the PVC tubing (approx. 2 foot) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap to the electronic calibrator.
4. Turn the electronic calibrator and sampling pump on. Create a bubble at the bottom of the flow chamber by pressing the bubble initiate button. The bubble should rise to the top of the flow chamber. After the bubble runs its course, the flow rate is shown on the LED display.
5. Turn the flow adjust screw or knob on the pump until the desired flow rate is attained.

6. Perform the calibration three times until the desired flow rate of $\pm 5\%$ is attained.

7.2.2 Calibrating a Rotameter with an Electronic Calibrator

1. See manufacturer's manual for operational instructions.
2. Set up the calibration train as shown in (Figure 4, Appendix B) using a sampling pump, rotameter, and electronic calibrator.
3. Assemble the base of the flow meter with the screw provided and tighten in place. The flow meter should be mounted within 6° vertical.
4. Turn the electronic calibrator and sampling pump on.
5. Create a bubble at the bottom of the flow chamber by pressing the bubble initiate button. The bubble should rise to the top of the flow chamber. After the bubble runs its course, the flow rate is shown on the LED display.
6. Turn the flow adjust screw or knob on the pump until the desired flow rate is attained.
7. Record the electronic calibrator flow rate reading and the corresponding rotameter reading. Indicate these values on the rotameter (sticker). The rotameter should be able to work within the desired flow range. Readings can also be calibrated for 10 cm³ increments for Low Flow rotameters, 500 cm³ increments for medium flow rotameters and 1 liter increments for high flow rotameters.
8. Perform the calibration three times until the desired flow rate of $\pm 5\%$ is attained. Once on site, a secondary calibrator, i.e., rotameter may be used to calibrate sampling pumps.

7.2.3 Calibrating a Personal Sampling Pump with a Rotameter

1. See manufacturer's manual for Rotameter's Operational Instructions.

2. Set up the calibration train as shown in (Figure 5, Appendix B) using a rotameter, sampling pump, and a representative sampling cassette.
3. To set up the calibration train, attach one end of the PVC tubing (approx. 2 ft) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap to the rotameter.
4. Assemble the base of the flow meter with the screw provided and tighten in place. The flow meter should be mounted within 6° vertical.
5. Turn the sampling pump on.
6. Turn the flow adjust screw (or knob) on the personal sampling pump until the float ball on the rotameter is lined up with the precalibrated flow rate value. A sticker on the rotameter should indicate this value.
7. A verification of calibration is generally performed on-site in the clean zone immediately prior to the sampling.
3. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety plan.
4. Once on-site the calibration is performed in the clean zone. The calibration procedures are listed in Section 7.2.
5. After calibrating the sampling pump, mobilize to the sampling location.

7.4.2 Site Sampling

1. To set up the sampling train, attach the air intake hose to the cassette base. Remove the cassette cap (Figure 6 and 7, Appendix B). The cassette should be positioned downward, perpendicular to the wind
2. If AC or DC electricity is required then turn it on. If used, the generator should be placed 10 ft. downwind from the sampling pump.
3. Record the following in a field logbook: date, time, location, sample identification number, pump number, flow rate, and cumulative time.
4. Turn the pump on. Should intermittent sampling be required, sampling filters must be covered between active periods of sampling. To cover the sample filter: turn the cassette to face upward, place the cassette cap on the cassette, remove the inlet plug from the cassette cap, attach a rotameter to the inlet opening of the cassette cap to measure the flow rate, turn off the sampling pump, place the inlet plug into the inlet opening on the cassette cap. To resume sampling: remove the inlet plug, turn on the sampling pump, attach a rotameter to measure the flow rate, remove the cassette cap, replace the inlet plug in the cassette cap and invert the cassette, face downward and perpendicular to the wind.
5. Check the pump at sampling midpoint if sampling is longer than 4 hours. The generators may need to be regased depending on tank size. If a filter darkens in appearance or if loose dust is seen in the filter, a second sample should be started.

7.3. Meteorology

It is recommended that a meteorological station be established. If possible, sample after two to three days of dry weather and when the wind conditions are at 10 mph or greater. Record wind speed, wind direction, temperature, and pressure in a field logbook. Wind direction is particularly important when monitoring for asbestos downwind from a fixed source.

7.4 Ambient Sampling Procedures

7.4.1 Pre-site Sampling Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
2. Obtain necessary sampling equipment and ensure it is in working order and fully charged (if necessary).

6. At the end of the sampling period, orient the cassette up, turn the pump off.
7. Check the flow rate as shown in Section 7.2.3. When sampling open-faced, the sampling cap should be replaced before post calibrating. Use the same cassette used for sampling for post calibration (increase dust/fiber loading may have altered the flow rate).
8. Record the post flow rate.
9. Record the cumulative time or run.
10. Remove the tubing from the sampling cassette. Still holding the cassette upright, replace the inlet plug on the cassette cap and the outlet plug on the cassette base.

7.4.3. Post Site Sampling

1. Follow handling procedures in Section 3.2, steps 1-4.
2. Obtain an electronic or hard copy of meteorological data which occurred during the sampling event. Record weather: wind speed, ambient temperature, wind direction, and precipitation. Obtaining weather data several days prior to the sampling event can also be useful.

7.5 Indoor Sampling Procedures

PCM analysis is used for indoor air samples. When analysis shows total fiber count above the OSHA action level 0.1 f/cc then TEM (U.S. EPA's Modified Yamate Method) is used to identify asbestos from non-asbestos fibers.

Sampling pumps should be placed four to five feet above ground level away from obstructions that may influence air flow. The pump can be placed on a table or counter. Refer to Table 2 (Appendix A) for a summary of indoor sampling locations and rationale for selection.

Indoor sampling utilizes high flow rates to increased sample volumes (2000 L for PCM and 2800 to 4200 L for TEM) in order to obtain lower detection limits below the standard, (i.e., 0.01 f/cc or lower [PCM]

and 0.005 structures/cc or lower [TEM]).

7.5.1 Aggressive Sampling Procedures

Sampling equipment at fixed locations may fail to detect the presence of asbestos fibers. Due to limited air movement, many fibers may settle out of the air onto the floor and other surfaces and may not be captured on the filter. In the past, an 8-hour sampling period was recommended to cover various air circulation conditions. A quicker and more effective way to capture asbestos fibers is to circulate the air artificially so that the fibers remain airborne during sampling. The results from this sampling option typifies worst case condition. This is referred to as aggressive air sampling for asbestos. Refer to Table 2 for sample station locations.

1. Before starting the sampling pumps, direct forced air (such as a 1-horsepower leaf blower or large fan) against walls, ceilings, floors, ledges, and other surfaces in the room to initially dislodge fibers from surfaces. This should take at least 5 minutes per 1000 sq. ft. of floor.
2. Place a 20-inch fan in the center of the room. (Use one fan per 10,000 cubic feet of room space.) Place the fan on slow speed and point it toward the ceiling.
3. Follow procedures in Section 7.4.1 and 7.4.2 (Turn off the pump and then the fan(s) when sampling is complete.).
4. Follow handling procedures in Section 3.2, steps 1-4.

8.0 CALCULATIONS

The sample volume is calculated from the average flow rate of the pump multiplied by the number of minutes the pump was running (volume = flow rate X time in minutes). The sample volume should be submitted to the laboratory and identified on the chain of custody for each sample (zero for lot, field and trip blanks).

The concentration result is calculated using the sample volume and the numbers of asbestos structures reported after the application of the cluster and matrix counting criteria.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

Follow all QA/QC requirements from the laboratories as well as the analytical methods.

9.1 TEM Requirements

1. Examine lot blanks to determine the background asbestos structure concentration.
2. Examine field blanks to determine whether there is contamination by extraneous asbestos structures during specimen preparation.
3. Examine of laboratory blanks to determine if contamination is being introduced during critical phases of the laboratory program.
4. To determine if the laboratory can satisfactorily analyze samples of known asbestos structure concentrations, reference filters shall be examined. Reference filters should be maintained as part of the laboratory's Quality Assurance program.
5. To minimize subjective effects, some specimens should be recounted by a different microscopist.
6. Asbestos laboratories shall be accredited by the National Voluntary Laboratory Accreditation Program.
7. At this time, performance evaluation samples for asbestos in air are not available for Removal Program Activities.

9.2 PCM Requirements

1. Examine reference slides of known concentration to determine the analyst's ability to satisfactorily count fibers. Reference slides should be maintained as part of the laboratory's quality assurance program.
2. Examine field blanks to determine if there is contamination by extraneous structures during sample handling.

3. Some samples should be relabeled then submitted for counting by the same analyst to determine possible bias by the analyst.
4. Participation in a proficiency testing program such as the AIIIA-NIOSH proficiency analytical testing (PAT) program.

10.0 DATA VALIDATION

Results of quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results accordingly with the project's data quality objectives.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety procedures. More specifically, when entering an unknown situation involving asbestos, a powered air purifying respirator (PAPR) (full face-piece) is necessary in conjunction with HEPA filter cartridges. See applicable regulations for action level, PEL, TLV, etc. If previous sampling indicates asbestos concentrations are below personal health and safety levels, then Level D personal protection is adequate.

12.0 REFERENCES

- (1) Environmental Asbestos Assessment Manual, Superfund Method for the Determination of Asbestos in Ambient Air, Part 1: Method, EPA/540/2-90/005a, May 1990, and Part 2: Technical Background Document, EPA/540/2-90/005b, May 1990.
- (2) Methodology for the Measurement of Airborne Asbestos by Electron Microscopy, EPA's Report No. 68-02-3266, 1984, G. Yamate, S.C. Agarwal, and R. D. Gibbons.
- (3) National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Method. Third Edition. 1987.
- (4) U.S. Environmental Protection Agency. Code of Federal Regulations 40 CFR 763. July 1, 1987. Code of Federal Regulations 40 CFR 763 Addendum. October 30, 1987.

15 U.S. Environmental Protection Agency.
Asbestos-Containing Materials in Schools;
Final Rule and Notice. 52 FR 41826.

60 Occupational Safety and Health
Administration. Code of Federal Regulations
29 CFR 1910.1001. Washington, D.C.
1987.

APPENDIX A

Tables

<p style="text-align: center;">TABLE 1.</p> <p style="text-align: center;">SAMPLE STATIONS FOR OUTDOOR SAMPLING</p>		
Sample Station Location	Sample Numbers	Rationale
Upwind/Background ⁽¹⁾	Collect a minimum of two simultaneous upwind/background samples 30° apart from the prevailing windlines.	Establishes background fiber levels.
Downwind	Deploy a minimum of 3 sampling stations in a 180 degree arc downwind from the source.	Indicates if asbestos is leaving the site.
Site Representative and/or Worst Case	Obtain one site representative sample which shows average condition on-site or obtain worst case sample (optional).	Verify and continually confirm and document selection of proper levels of worker protection.

⁽¹⁾ More than one background station may be required if the asbestos originates from different sources.

APPENDIX A (Cont'd)

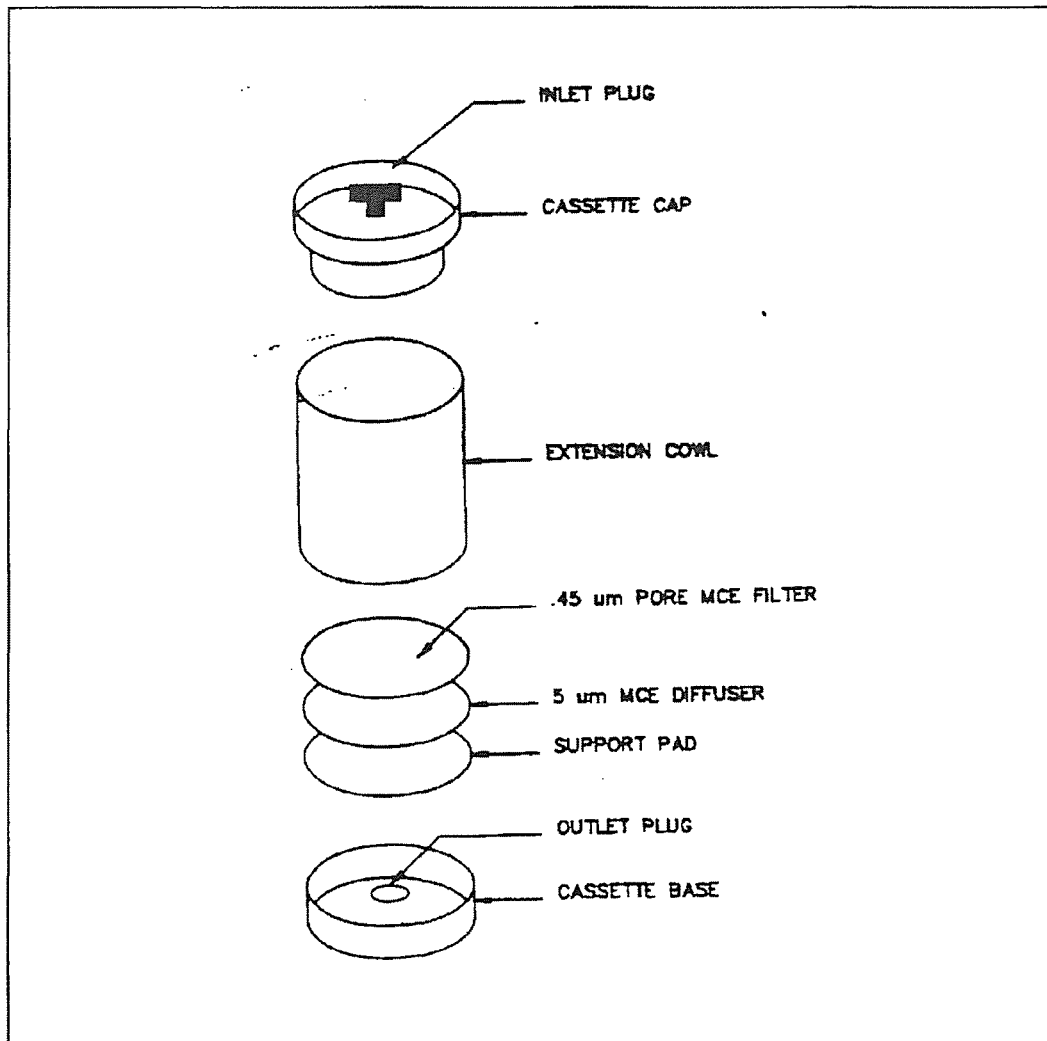
Tables

<p style="text-align: center;">TABLE 2</p> <p style="text-align: center;">SAMPLE STATIONS FOR INDOOR SAMPLING</p>		
Sample Station Location	Sample Numbers	Rationale
Indoor Sampling	<p>If a work site is a single room, disperse 5 samplers throughout the room.</p> <p>If the work site contains up to 5 rooms, place at least one sampler in each room.</p> <p>If the work site contains more than 5 rooms, select a representative sample of the rooms.</p>	Establishes representative samples from a homogeneous area.
Upwind/Background	If outside sources are suspected, deploy a minimum of two simultaneous upwind/background samples 30° apart from the prevailing windlines.	Establish whether indoor asbestos concentrations are coming from an outside source.
Worst Case	Obtain one worst case sample, i.e., aggressive sampling (optional).	Verify and continually confirm and document selection of proper levels of worker protection.

APPENDIX B

Figures

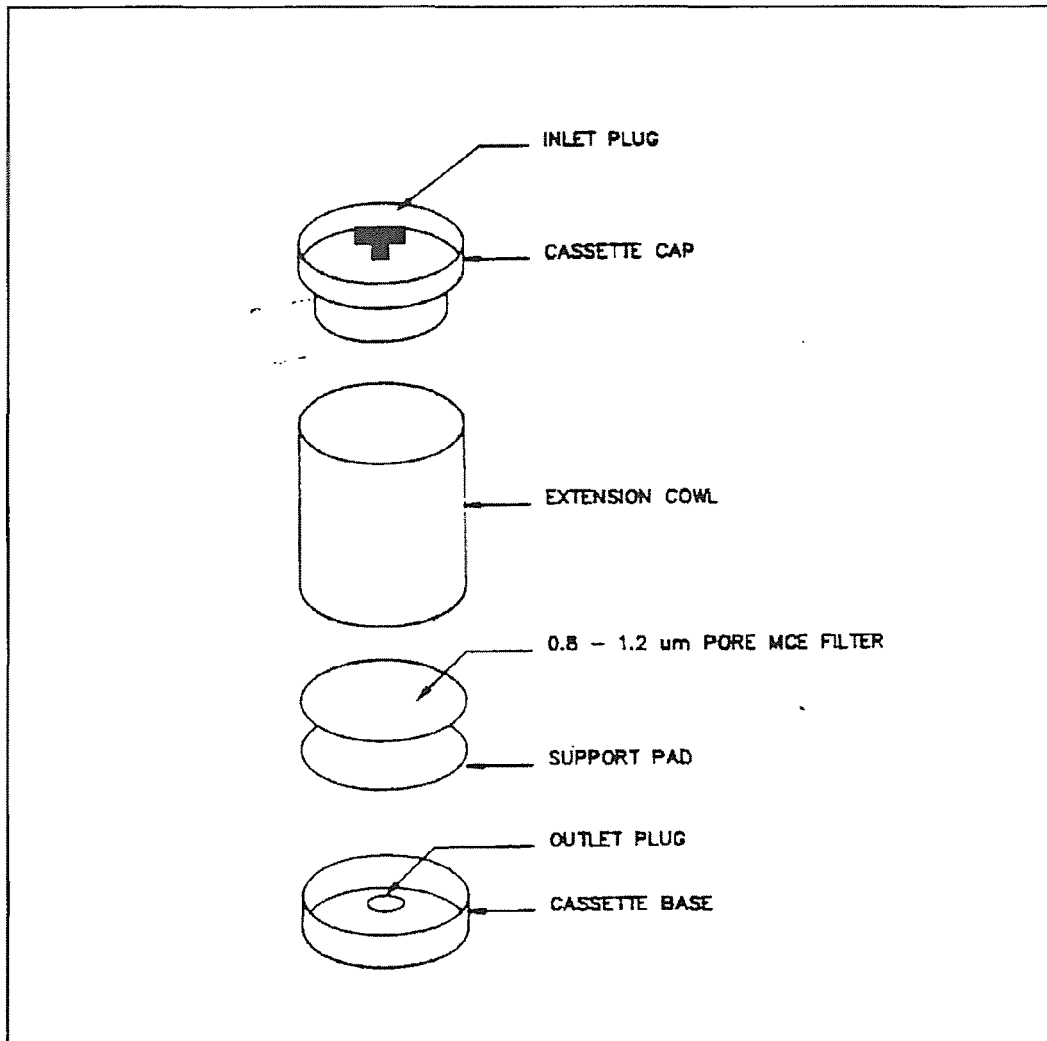
FIGURE 1. Transmission Electron Microscopy Filter Cassette



APPENDIX B (Cont'd)

Figures

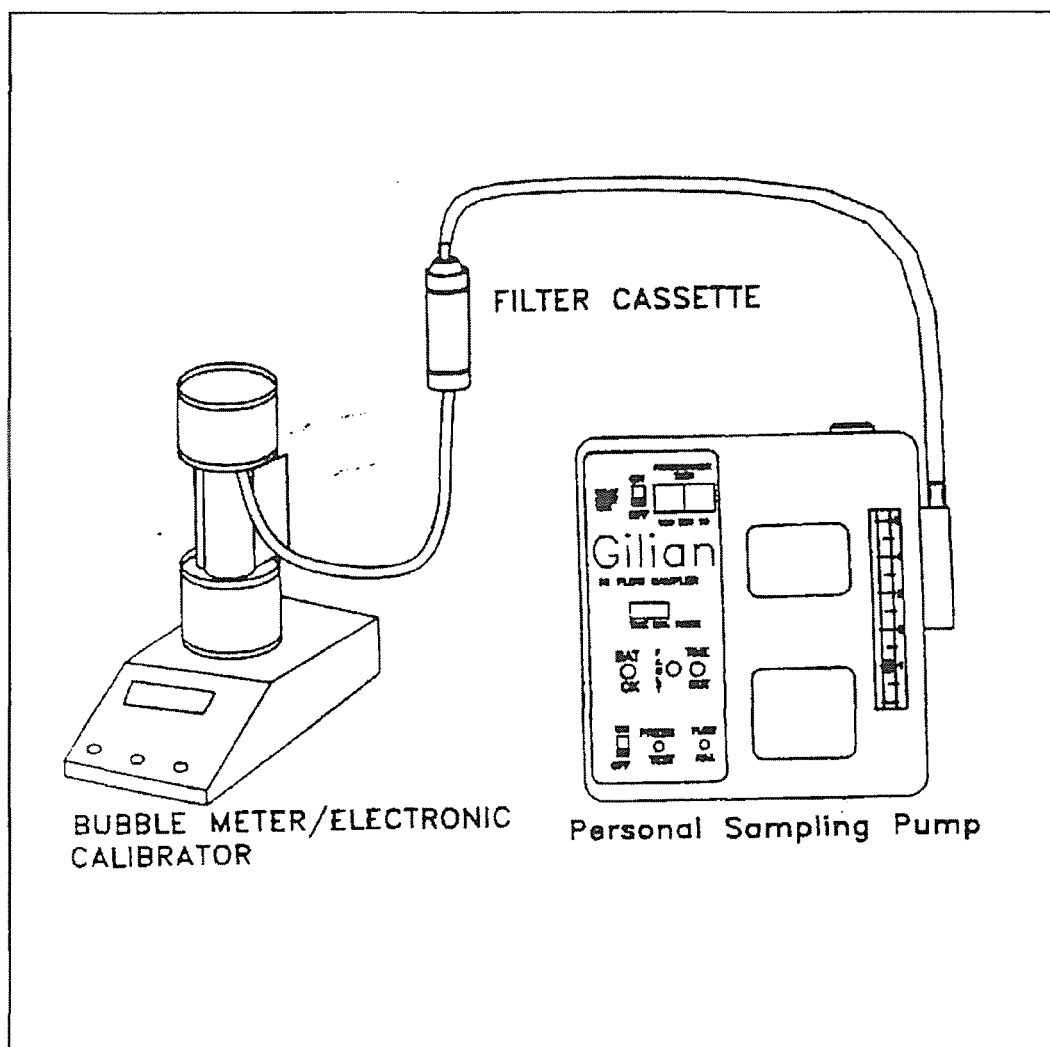
FIGURE 2. Phase Contrast Microscopy Filter Cassette



APPENDIX B (Cont'd)

Figures

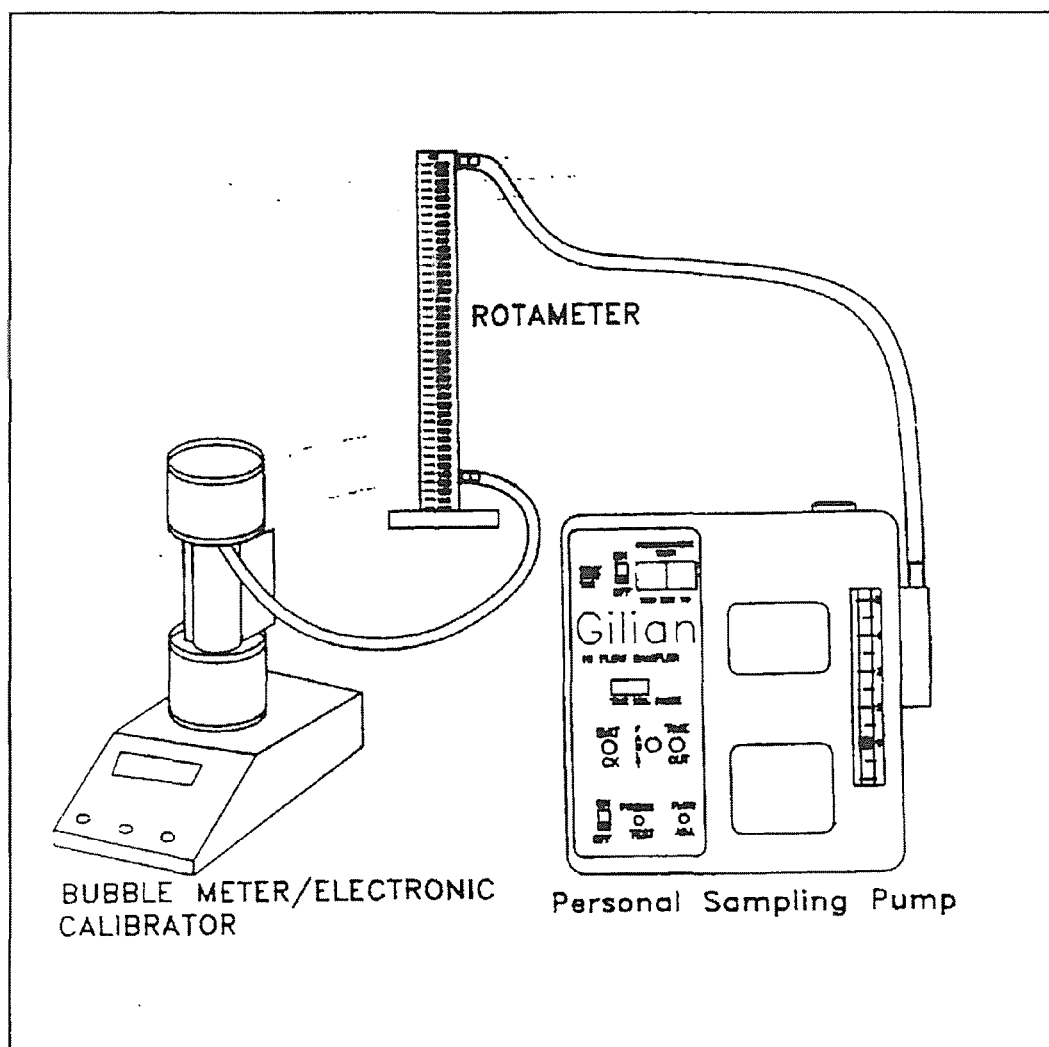
FIGURE 3. Calibrating a Personal Sampling Pump with a Bubble Meter



APPENDIX B (Cont'd)

Figures

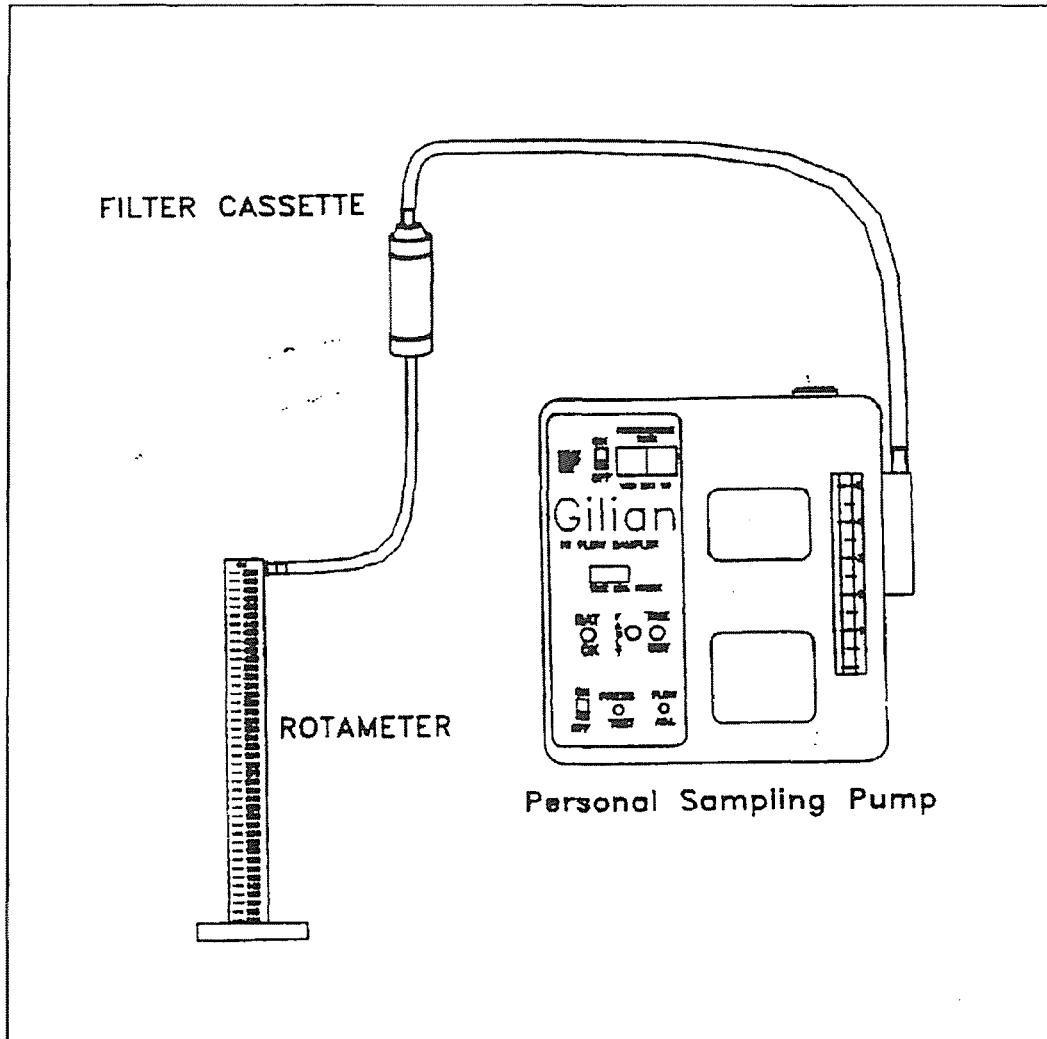
FIGURE 4. Calibrating a Rotameter with a Bubble Meter



APPENDIX B (Cont'd)

Figures

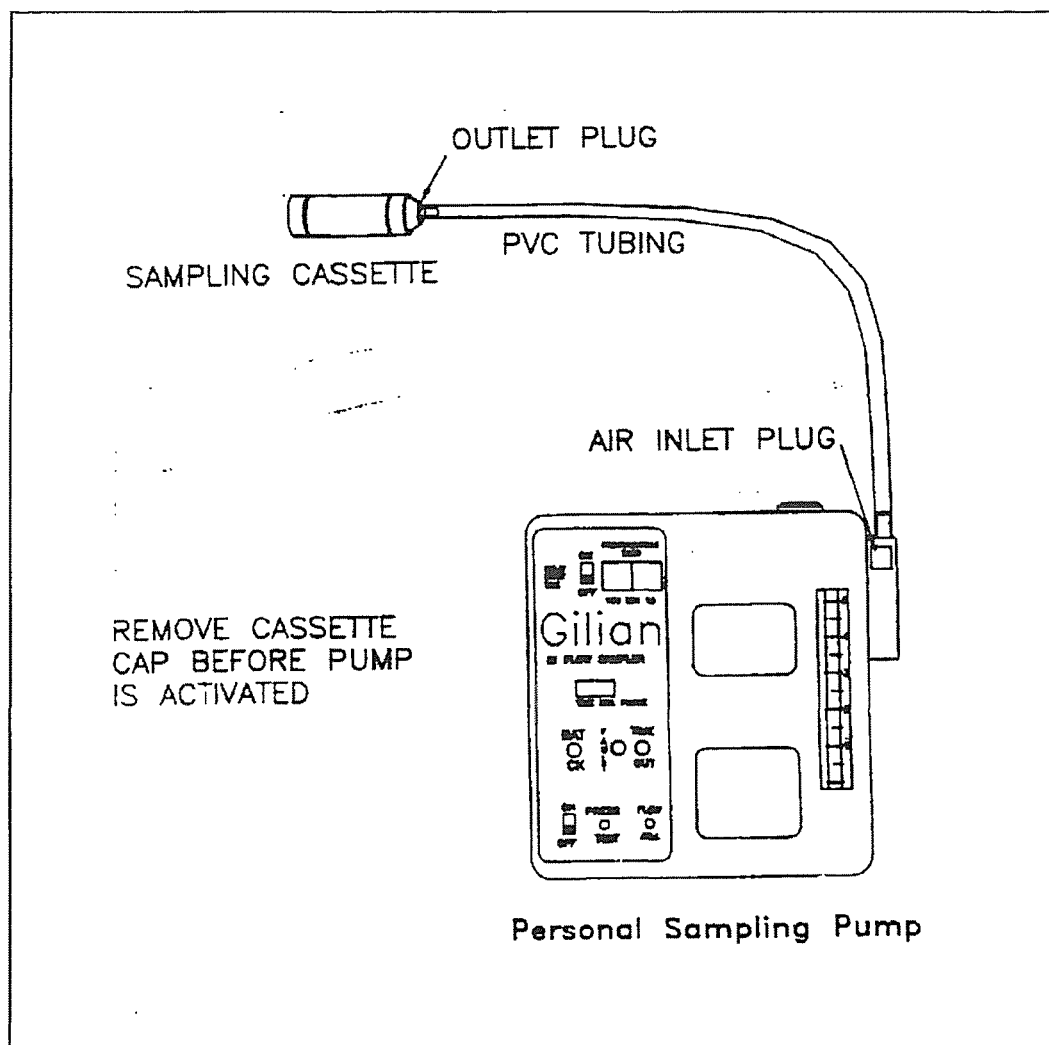
FIGURE 5. Calibrating a Sampling Pump with a Rotameter



APPENDIX B (Cont'd)

Figures

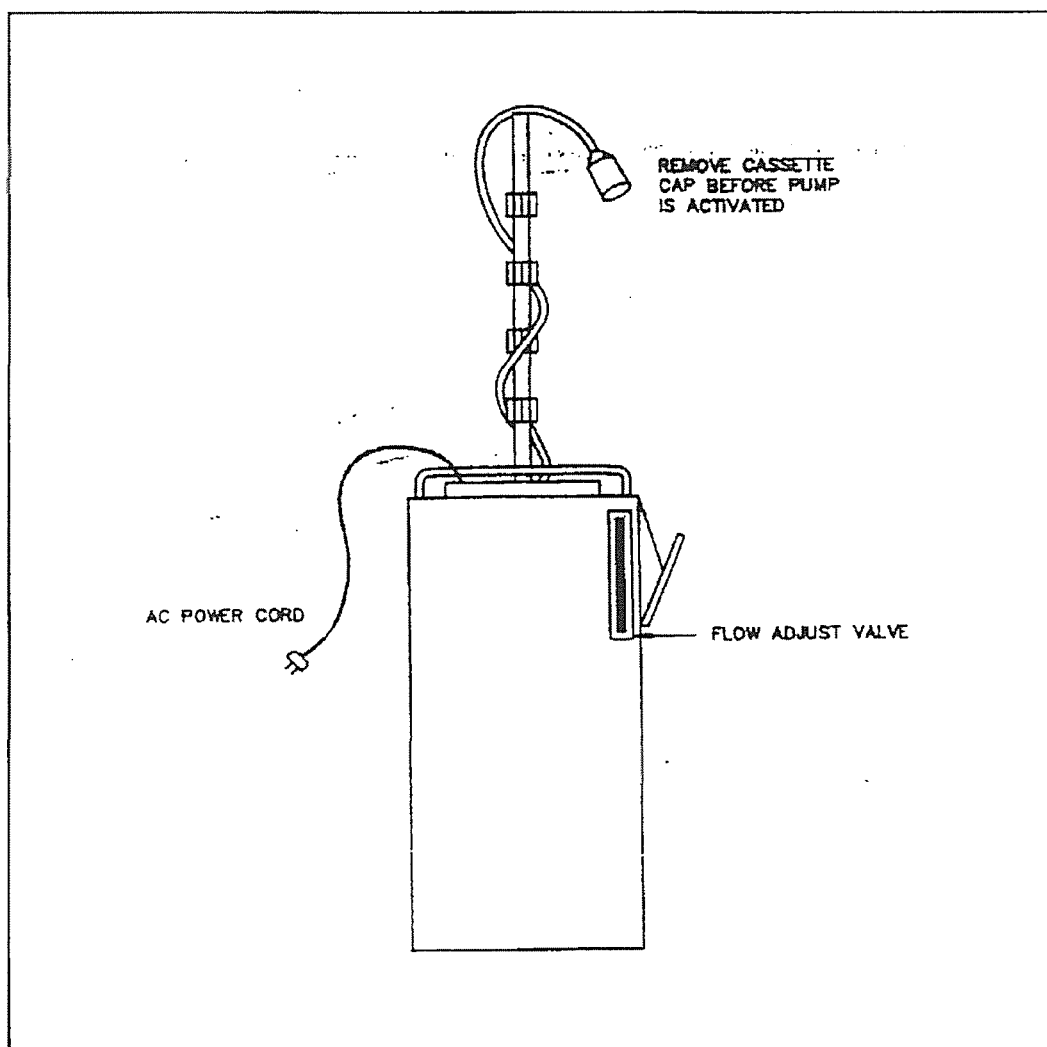
FIGURE 6. Personal Sampling Train for Asbestos



APPENDIX B (Cont'd)

Figures

FIGURE 7. High Flow Sampling Train for Asbestos



Appendix E

General Air Sampling Guidelines (EPA SOP 2008, Revision 0.0)



GENERAL AIR SAMPLING GUIDELINES

SOP#: 2008
DATE: 11/16/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides guidance in developing and implementing sampling plans to assess the impact of hazardous waste sites on ambient air. It presents the United States Environmental Protection Agency/Environmental Response Team's (U.S. EPA/ERT's) approach to air sampling and monitoring and identifies equipment requirements. It is not within the scope of this SOP to provide a generic air sampling plan. Experience, objectives, site characteristics, and chemical characteristics will dictate sampling strategy. This SOP does not address indoor air sampling.

Two basic approaches can be used to assess ambient air (also referred to as air pathway assessments): modeling and measurements. The modeling approach initially estimates or measures the overall site emission rate(s) and pattern(s). These data are input into an appropriate air dispersion model, which predicts either the maximum or average air concentrations at selected locations or distances during the time period of concern. This overall modeling strategy is presented in the first three volumes of the Air Superfund National Technical Guidance Series on Air Pathway Assessments^(1,2,3). Specific applications of this strategy are presented in several additional Air Superfund Technical Guidance documents⁽⁴⁾.

The measurement approach involves actually measuring the air impact at selected locations during specific time periods. These measurements can be used to document actual air impacts during specific time intervals (i.e., during cleanup operations) or to extrapolate the probable "worst case" concentrations at that and similar locations over a longer time period than was sampled.

This SOP addresses issues associated with this second assessment strategy. This SOP also discusses the U.S. EPA/ERT's monitoring instruments, air sampling

kits, and approach to air sampling and monitoring at hazardous waste sites.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air monitoring is defined as the use of direct-reading instruments and other screening or monitoring equipment and techniques that provide instantaneous (real-time) data on the levels of airborne contaminants. The U.S. EPA/ERT maintains numerous monitors for real-time measurements. Examples of air monitoring equipment are hand-held photoionization detectors (PID), flame ionization detectors (FID), oxygen/combustible gas detectors, and remote optical sensors.

Air sampling is defined as those sampling and analytical techniques that require either off- or on-site laboratory analysis and therefore do not provide immediate results. Typically, air sampling occurs after use of real-time air monitoring equipment has narrowed the number of possible contaminants and has provided some qualitative measurement of contaminant concentration. Air sampling techniques are used to more accurately detect, identify and quantify specific chemical compounds relative to the majority of air monitoring technologies.

In the Superfund Removal Program, On-Scene Coordinators (OSCs) may request the U.S. EPA/ERT to conduct air monitoring and sampling during the

following situations: emergency responses, site assessments, and removal activities. Each of these activities has a related air monitoring/sampling objective that is used to determine the potential hazards to workers and/or the community.

- **Emergency Response**

Emergency responses are immediate responses to a release or threatened release of hazardous substances presenting an imminent danger to public health, welfare, or the environment (i.e., chemical spills, fires, or chemical process failures resulting in a controlled release of hazardous substances). Generally these situations require rapid on-site investigation and response. A major part of this investigation consists of assessing the air impact of these releases.

- **Removal Site Assessment**

Removal site assessments (referred to as site assessments) are defined as any of several activities undertaken to determine the extent of contamination at a site and which help to formulate the appropriate response to a release or threatened release of hazardous substances. These activities may include a site inspection, multimedia sampling, and other data collection.

- **Removal Actions**

Removal actions clean up or remove hazardous substances released into the environment. Removal actions include any activity conducted to abate, prevent, minimize, stabilize, or eliminate a threat to public health or welfare, or to the environment.

Personal risk from airborne contaminants can be determined by comparing the results of on-site monitoring and sampling to health-based action levels such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). Residential risk can be determined by comparing the results of off-site monitoring or sampling to health-based action levels such as those developed by the Agency for Toxic Substance and

Disease Registry (ATSDR).

The extent to which valid inferences can be drawn from air monitoring/sampling depends on the degree to which the monitoring/sampling effort conforms to the objectives of the event. Meeting the project's objectives requires thorough planning of the monitoring/sampling activities, and implementation of the most appropriate monitoring/sampling and analytical procedures. These issues will be discussed in this SOP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Preservation, containers, handling and storage for air samples are discussed in the specific SOPs for the technique selected. In addition, the analytical method (i.e., U.S. EPA, National Institute for Occupational Safety and Health [NIOSH], and OSHA Methods) may be consulted for storage temperature, holding times and packaging requirements. After sample collection, the sampling media (i.e., cassettes or tubes) are immediately sealed. The samples are then placed into suitable containers (i.e., whirl bags, resealable bags or culture tubes) which are then placed into a shipping container.

Use bubble wrap or styrofoam peanuts when packing air samples for shipment. **DO NOT USE VERMICULITE.**

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentration. Natural sources, such as biological waste, can produce hydrogen sulfide and methane which may contribute to the overall contaminant level. Extraneous anthropogenic contaminants (i.e., burning of fossil fuels; emissions from vehicular traffic, especially diesel; volatile compounds from petrochemical facilities; and effluvium from smoke stacks) may also contribute. Air sampling stations should be strategically placed to identify contributing sources.

Photoreactivity or reaction of the parameters of concern may occur with nonrelated compounds [i.e., nitrogen compounds and polyaromatic hydrocarbons

(PAHs)]. Some sorbent media/samples should not be exposed to light during or after sampling due to photochemical effects (i.e., PAHs).

Various environmental factors, including humidity, temperature and pressure, also impact the air sampling methodology, collection efficiency and detection limit. Since the determination of air contaminants is specifically dependent on the collection parameters and efficiencies, the collection procedure is an integral part of the analytical method.

Detection limits depend on the contaminants being investigated and the particular site situation. It is important to know why the data are needed and how the data will be used. Care should be taken to ensure the detection limits are adequate for the intended use of the final results.

Some equipment may be sensitive to humidity and temperature extremes.

5.0 EQUIPMENT/APPARATUS

5.1 Direct Reading Instruments (Air Monitoring Instruments)

There are two general types of direct reading instruments: portable screening devices and specialized analytical instruments. Generally all these techniques involve acquiring, for a specific location or area, continuous or sequential direct air concentrations in either a real-time or semi-real-time mode. None of these instruments acquires true time-weighted average concentrations. In addition, these instruments are not capable of acquiring simultaneous concentration readings at multiple locations, although several are able to sequentially analyze samples taken remotely from different locations. The document, "Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Waste Sites⁽⁵⁾," provides additional information about air sampling and monitoring. The hazard levels for airborne contaminants vary. See the ACGIH TLVs and the OSHA PELs for safe working levels. Common screening devices and analytical instruments are described in Appendix A.

5.2 Air Sampling Equipment and Media/Devices

The U.S. EPA/ERT uses the following analytical

methods for sampling: *NIOSH Manual of Analytical Methods*⁽⁶⁾, *American Society for Testing and Materials (ASTM) Methods*⁽⁷⁾, *U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*^(8,9), and *OSHA Methods*⁽¹⁰⁾. Additional air sampling references include *Industrial Hygiene and Toxicology* (3rd Ed.)⁽¹¹⁾ and *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*⁽¹²⁾. These methods typically specify equipment requirements for sampling. Since air sampling is such a diverse technology, no single method or reference is best for all applications. Common sampling equipment and media/devices are described in Appendix B.

5.3 Tools/Material and Equipment List

In addition to equipment and materials identified in Appendices A and B, the following equipment and materials may be required to conduct air sampling and monitoring at hazardous waste sites:

- Camera
- Site logbook
- Clipboard
- Chain of custody records
- Custody seals
- Air sampling worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil
- Extension cords
- Glass cracker
- Multiple plug outlet
- Whirl bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon[®] tubing
- Surgical gloves
- Lint-free gloves
- Ice
- Sample container

Use the following additional equipment when decontaminating glassware on site:

- Protective equipment (i.e., gloves, splash goggles, etc.)
- Appropriate solvent(s)
- Spray bottles
- Liquinox (soap)
- Paper towels

- Distilled/deionized water
- Five-gallon buckets
- Scrub brushes and bottle brushes

6.0 REAGENTS

Impinger sampling involves using reagents contained in a glass vial to absorb contaminants of concern (for example, NIOSH Method 3500 for formaldehyde uses 1% sodium bisulfite solution). Impinger solutions vary and are method-dependent.

Reagents such as acetone and hexane are required to decontaminate glassware and some air sampling equipment. Decontamination solutions are specified in the Sampling Equipment Decontamination SOP.

7.0 PROCEDURES

7.1 Air Monitoring Design

7.1.1 Initial Surveys

In general, the initial survey is considered to be a relatively rapid screening process for collecting preliminary data at hazardous waste sites. However, initial surveys may require many hours to complete and may consist of more than one entry.

Some information is generally known about the site; therefore, real-time instrumentation for specific compounds (i.e., detector tubes and electrochemical sensors) can be used to identify hot spots. Sufficient data should be obtained with real-time instruments during the initial entry to screen the site for various contaminants. When warranted, intrinsically safe or explosion-proof instruments should be used. An organic vapor analyzer (OVA) is typically used during this survey. These gross measurements may be used on a preliminary basis to (1) determine levels of personal protection, (2) establish site work zones, and (3) map candidate areas for more thorough qualitative and quantitative studies involving air sampling.

In some situations, the information obtained may be sufficient to preclude additional monitoring. Materials detected during the initial survey may call for a more comprehensive evaluation of hazards and analyses for specific compounds. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be established.

7.1.2 Off-Site Monitoring

Typically, perimeter monitoring with the same instruments employed for on-site monitoring is utilized to determine site boundaries. Because air is a dynamic matrix, physical boundaries like property lines and fences do not necessarily delineate the site boundary or area influenced by a release. Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments. Monitoring at the fenceline or at varying locations off site provides useful information regarding pollutant migration. Three to four locations downwind of the source (i.e., plume) at breathing-zone height, provide a basic fingerprint of the plume. Negative instrument readings off site should not be interpreted as the complete absence of airborne toxic substances; rather, they should be considered another piece of information to assist in the preliminary evaluation. The interpretation of negative readings is instrument-dependent. The lack of instrument readings off site should not be interpreted as the complete absence of all airborne toxic substances; rather, it is possible that the particular compound or class of compounds to which the monitoring instrument responds is not present or that the concentration of the compound(s) is below the instrument's detection limit.

7.2 Air Sampling Design

7.2.1 Sampling Plan Design

The goal of air sampling is to accurately assess the impact of a contaminant source(s) on ambient air quality. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern. This variability plays a major role in designing an air sampling plan.

Downwind air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local

meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. All of these concerns must be incorporated into an air sampling plan.

A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of stationary as well as mobile sources
- Analytes of concern
- Analytical detection limit to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern as well as background contributions be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of QA/QC samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by placing samplers upwind, downwind and crosswind from the subject source. The analytical data from these different sampling locations may be compared to determine statistical differences.

7.2.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the sampling plan. Does the sampling plan verify adequate levels of protection for on-site personnel, or address potential off-site impacts

associated with the site or with site activities? In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," "worst case," or "one-time" conditions. If the conditions present at the time of sampling are different from those assumed during the development of the sampling plan, then quality of the data collected may be affected. The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.
- Worst case: sampling conducted under the worst meteorological and/or site conditions which would result in elevated ambient concentrations.
- One-time: only one chance is given to collect a sample without regard to time or conditions.

Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long time interval.

The sampling objectives also dictate the detection limits. Sampling methods for airborne contaminants will depend upon the nature and state (solid, liquid or gas) of the contaminant. Gases and vapors may be collected in aqueous media or adsorbents, in molecular sieves, or in suitable containers. Particulates are collected by filters or impactors. The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired detection limit. A sufficient amount of sample must be collected to achieve the desired detection limit without interference from other contaminants. In addition, the selected method must be able to detect the target compound(s).

7.2.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the

sampling and analytical methods being utilized, the variability of contaminant concentration over time at the site, the level of precision required and cost limitations. In addition, determine the number of locations and placement of samplers by considering the nature of the response, local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.
- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.
- Topographic features that affect the dispersion and transport of airborne toxic constituents.

Avoid natural obstructions when choosing air sampling station locations, and account for channelization around those obstructions.

- Large water bodies, which affect atmospheric stability and the dispersion of air contaminants.
- Roadways (dirt or paved), which may generate dust that could mask site contaminants.
- Vegetation, such as trees and shrubs, which stabilizes soil and retards subsurface contaminants from becoming airborne. It also affects air flow and scrubs some contaminants from the air. Sometimes thick vegetation can make an otherwise ideal air monitoring location inaccessible.

Consider the duration of sampling activities when choosing the location and number of samples to be collected. For example, if the sampling period is limited to a few hours, one or two upwind and several downwind samples would typically be adequate,

especially around major emission sources.

A short-term monitoring program ranges from several days to a few weeks and generally includes gathering data for site assessments, removal actions, and source determination data (for further modeling). Activities involved in a short-term sampling strategy must make the most of the limited possibilities for data collection. Consider moving upwind/downwind locations daily based on National Oceanic and Atmospheric Administration (NOAA) weather forecasts. Weather monitoring becomes critical where complex terrain and local meteorological effects frequently change wind direction. Often, a number of alternatives can fulfill the same objective.

Prevailing winds running the length of a valley usually require a minimum number of sampler locations; however, a complex valley may require more sampler locations to account for the wide variety of winds. Ocean/lake effects may require a radical plan to collect enough samples to reach a low detection limit. Two sets of samplers may be placed next to each other: one set would be activated during the sea breeze while the other set is turned off, and vice versa when there is no sea breeze. After the sampling event, the respective upwind and downwind samples would be combined. Another alternative for sampling near a large body of water may be to use automatic, wind-vector-operated samplers, which turn the sampler on only when the wind comes from a specified vector. At sites located on hillsides, wind will move down a valley and produce an upward fetch at the same time. Sampling locations may have to ring the site to measure the wind's impact.

Off-site sources may affect on-site monitoring. In this case, on-site meteorological data, concurrent with sampling data, is essential to interpreting the acquired data. Also, additional upwind sampling sites may be needed to fully characterize ambient background contaminant levels. Multiple off-site sources may require several monitoring locations, but if the sources are at a sufficient distance, only one monitoring location is needed.

Topography and weather are not the only factors in sampler location; the sampling sites must be secure from vandals and mishap. Secure all sampling locations to maintain chain of custody, and to prevent tampering with samples or loss of sampling units. High-volume sampling methods often require the use of 110 VAC electric power. When portable

generators are used, the power quality may affect sampler operation. Also, be aware that the generators themselves could be a potential pollution source if their placement is not carefully considered.

Air quality dispersion models can be used to place samplers. The models incorporate source information, surrounding topography, and meteorological data to predict the general distance and directions of maximum ambient concentrations. Modeling results should be used to select sampling locations in areas of maximum pollutant concentrations.

7.2.4 Time, Duration and Frequency of Sampling Events

After choosing appropriate sampling or monitoring locations, determine the sampling frequency and the number of samples to be collected. The time of day, duration and frequency of sampling events is governed by:

- The effects of site activities and meteorology on emission rates
- The diurnal effect of the meteorology on downwind dispersion
- The time period(s) of concern as defined by the objective
- The variability in the impact from other non-site-related sources
- If defined, the degree of confidence needed for either the mean or maximum downwind concentrations observed
- The precision requirements for single measurements
- Cost and other logistical considerations

The duration of the removal action and the number of hours per day that site work is conducted determine the time, duration, and frequency of samples. Short-term sampling programs may require daily sampling, while long-term programs may require 24-hour sampling every sixth or twelfth day. If the site will be undergoing removal activities 24 hours a day, continuous air sampling may be warranted. However, if the site activities will be conducted for only eight hours a day, and there are no emissions likely to occur during the remaining 16 hours, then sampling would be appropriate prior to the start of daily activities, would continue during operations, and end at the conclusion of the daily activities. An off-peak sample collection can ensure that emissions are not persisting

after the conclusion of daily cleanup activities. For some sites, emissions are still a factor several hours after daily site activities have been completed. Because of the typically decreased downwind dispersion in the evening, higher downwind concentrations than were present during daytime site activities may be detected. For sites where this is possible, the sampling duration needs to be lengthened accordingly.

Sampling duration and flow rate dictate the volume of air collected, and to a major degree, the detection limit. The analytical method selected will provide a reference to flow rate and volume. Flow rates are limited to the capacity of the pumps being employed and the contact time required by the collection media.

The duration or period of air sampling is commonly divided into two categories (1) samples collected over a brief time period are referred to as "instantaneous" or "grab" samples and are usually collected in less than five minutes and (2) average or integrated samples are collected over a significantly longer period of time. Integrated samples provide an average concentration over the entire sampling period. Integrated samples are not suited to determining cyclical releases of contaminants because periodic or cyclical events are averaged out by the proportionally long sampling duration.

Air quality dispersion models can predict the maximum air contaminant concentration expected from a source. The meteorological and site conditions expected to cause the highest concentration are known as worst-case conditions and can be identified by analyzing the modeling results. Depending upon the objective, one may sample when the model predicts worst-case conditions will exist.

7.2.5 Meteorological and Physical/Chemical Considerations

A meteorological monitoring program is an integral part of site monitoring activities. Meteorological data, which define local terrain impacts on air flow paths, are needed to interpret air concentration data. Meteorological data may be available from an existing station located near the site (i.e., at a local airport), otherwise a station should be set up at the site. This data will document the degree that samples actually were downwind and verify whether other worst-case assumptions were met. Meteorological parameters to

be monitored are, at a minimum, wind speed, wind direction, and sigma theta (which is the horizontal wind direction standard deviation and an indicator of atmospheric stability). The remaining parameters primarily affect the amount of a contaminant available in the air.

- **Wind Speed**

When the contaminant of concern is a particulate, wind speed is critical in determining whether the particulate will become airborne, the quantity of the particulate that becomes airborne, and the distance the particulate will travel from the source. Wind speed also contributes to the volatilization of contaminants from liquid sources.

- **Wind Direction**

Wind direction highly influences the path of airborne contaminants. In addition, variations in wind direction increase the dispersion of pollutants from a given source.

- **Atmospheric Stability**

Atmospheric stability refers to the degree to which the atmosphere tends to dampen vertical and horizontal motion. Stable atmospheric conditions (i.e., evenings) result in low dispersion, and unstable atmospheric conditions (i.e., hot sunny days) result in higher dispersion.

- **Temperature**

Higher temperatures increase the rate of volatilization of organic and some inorganic compounds and affect the initial rise of gaseous or vapor contaminants. Therefore, worst-case emission of volatiles and semivolatiles occurs at the hottest time of day, or on the hottest day.

- **Humidity**

High humidity affects water-soluble chemicals and particulates. Humid conditions may dictate the sampling media used to collect the air sample, or limit the volume of air sampled and thereby increase

the detection limit.

- **Atmospheric Pressure**

Migration of landfill gases through the landfill surface and through surrounding soils are governed by changes in atmospheric pressure. Atmospheric pressure will influence upward migration of gaseous contaminants from shallow aquifers into the basements of overlying structures.

In many cases, the transport and dispersion of air pollutants is complicated by local meteorology. Normal diurnal variations (i.e., temperature inversions) affect dispersion of airborne contaminants. Terrain features can enhance or create air inversions and can also influence the path and speed of air flow, complicating transport and dispersion patterns.

The chemical characteristics of a contaminant (i.e., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds, and photodegradation) affects its behavior and can influence the method used to sample and analyze it.

8.0 CALCULATIONS

Volume is obtained by multiplying the sample time in minutes by the flow rate. Sample volume should be indicated on the chain of custody record. Adjustments for temperature and pressure differences may be required.

Results are usually provided in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter (mg/m³) or micrograms per cubic meter (μg/m³).

Refer to the analytical method or regulatory guidelines for other applicable calculations.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The manufacturer's instructions should be reviewed prior to instrument use. Instruments must be utilized in accordance with manufacturer's instructions. Equipment checkout and calibration activities must

occur prior to and after monitoring and sampling and must be documented.

9.1 QA/QC Samples

QA/QC samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies; then a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and matrix spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives.

9.2 Sample Documentation

All sample and monitoring activities should be documented legibly, in ink. Any corrections or revisions should be made by lining through the incorrect entry and by initialing the error. All samples must be recorded on an Air Sampling Worksheet. A chain of custody record must be maintained from the time a sample is taken to the final disposition of the sample. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples.

10.0 DATA VALIDATION

Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives.

11.0 HEALTH AND SAFETY

Personal protection equipment (PPE) requirements identified in federal and/or state regulations and 29 Code of Federal Regulations (CFR) 1910.120 for hazardous waste site work must be followed.

The majority of physical precautions involved in air sampling are related to the contaminant sampled. Attention should be given when sampling in

potentially explosive, flammable or acidic atmospheres. On rare occasions, the collection media may be hazardous; for example, in the instance where an acidic or basic solution is utilized in an impinger.

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

12.0 REFERENCES

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APPENDIX A

Portable Screening Devices and Specialized Analytical Instruments

PORTABLE SCREENING DEVICES

Where possible, a datalogger should be used to minimize the length of time required for site personnel to be in a potentially contaminated area. Datalogger cable is available from manufacturers for linear output instruments and some nonlinear output instruments. U.S. EPA ERT/REAC has output cables for organic vapor analyzers (i.e., HNU and OVA), toxic gas analyzers (i.e., monitox) and real-time aerosol monitors (i.e., RAM and miniram).

- **Total Hydrocarbon Analyzers**

Total hydrocarbon analyzers used to detect a variety of volatile organic compounds (VOCs) at hazardous waste sites principally employ either a photoionization detector (PID) or a flame ionization detector (FID). Compounds are ionized by a flame or an ultraviolet lamp. PIDs depend on the ionization potential of the compounds. PIDs are sensitive to aromatic and olefinic (unsaturated) compounds such as benzene, toluene, styrene, xylenes, and acetylene. Greater selectivity is possible by using low-voltage lamps. The ionization potential of individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. These instruments are not compound-specific and are typically used as screening instruments. FIDs are sensitive to volatile organic vapor compounds such as methane, propanol, benzene and toluene. They respond poorly to organic compounds lacking hydrocarbon characteristics.

- **Oxygen and Combustible Gas Indicators**

Combustible Gas Indicators (CGIs) provide efficient and reliable methods to test for potentially explosive atmospheres. CGI meters measure the concentration of a flammable vapor or gas in air and present these measurements as a percentage of the

lower explosive limit (LEL).

The measurements are temperature-dependent. The property of the calibration gas determines sensitivity.

LELs for individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. If readings approach or exceed 10% of the LEL, extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately.

CGIs typically house an electrochemical sensor to determine the oxygen concentration in ambient air. Normally, air contains approximately 20.9% oxygen by volume. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors which could displace ambient air. The meters are calibrated for sea level and may indicate a false negative (i.e., O₂ content) at higher altitudes. Since the air has been displaced by other substances, these oxygen-deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto-ignition.

- **Toxic Atmosphere Analyzers**

The toxic atmosphere analyzer is a compound-specific instrument, designed and calibrated to identify and quantify a specific compound or class of compounds in either gaseous or vapor form. Cross-sensitivity to air pollutants not of interest may lead to erroneous results.

U.S. EPA/ERT has the following toxic atmosphere analyzers: carbon monoxide, phosgene, nitrous oxide, hydrogen cyanide, sulfur dioxide, hydrogen sulfide, and chlorine gas.

- **Aerosol/Particulate Monitors**

A Real-Time Aerosol/Particulate Monitor (RAM) displays readings for total particulates. The instrument employs a pulse light emitting diode which generates a narrow band emission in conjunction with a photovoltaic cell to detect light scattered from particulates.

The U.S. EPA/ERT uses the RAM when the contaminant of concern is associated with particulates, and when responding to fires involving hazardous materials, to identify plume levels. The instrument is very useful in determining the presence of a plume when it is not visible. The U.S. EPA/ERT typically uses RAMs on tripods to obtain particulate concentrations at the breathing zone level. Personal dataloggers are used with the RAMs to document minimum, average and maximum concentrations. This provides real-time data without requiring those in personal protective equipment to be constantly present in the plume.

- **Chemical Detector Tubes (Colorimetric Tubes)**

A chemical detector tube is a hollow, tube-shaped, glass body containing one or more layers of chemically impregnated inert material. To use, the fused ends are broken off and a manufacturer-specified volume of air is drawn through the tube with a pump to achieve a given detection limit. The chemicals contained within the packing material undergo a chemical reaction with the airborne pollutant present, producing a color change during the intake of each pump stroke. The concentration of a pollutant is indicated by the length of discoloration on a calibrated scale printed on the detector tube.

- **Radiation Meters**

Radiation meters determine the presence and level of radiation. The meters use a gas or solid ion detection media which becomes ionized when radiation is present. The meters are normally calibrated to one probe. Meters that detect alpha, beta, and gamma radiation are available.

- **Gold Film (Hydrogen Sulfide and Mercury Vapor) Monitors**

Hydrogen sulfide (H_2S) and Mercury (Hg) monitors operate on the principle that electric resistivity increases across a gold film as a function of H_2S and Hg concentration. The monitors provide rapid and relatively low detection limits for H_2S and Hg in air. After extensive sampling periods or high concentrations of H_2S and Hg, the gold film must be heated to remove contamination and return the monitor to its original sensitivity.

- **Infrared Detectors**

Infrared detectors such as the Miniature Infrared Analyzer (MIRAN) use infrared (IR) absorption as a function of specific compounds. MIRAN instruments apply to situations where the contaminants are identified but concentrations are not. MIRAN instruments generally require AC power.

SPECIALIZED ANALYTICAL INSTRUMENTS

The continuous monitors described above provide qualitative measurement of air contaminants. Quantitative measurements in the field can be obtained using more sophisticated instruments, such as portable Gas Chromatographs, to analyze grab samples.

- **Direct Air Sampling Portable Gas Chromatographs (GCs)**

Portable GCs use gas chromatography to identify and quantify compounds. The time it takes for a compound to move through a chromatographic column is a function of that specific compound or group of compounds. A trained technician with knowledge of the range of expected concentrations of compounds can utilize a portable GC in the field to analyze grab samples. GCs generally require AC power and shelter to operate. This method is limited by its reliance on a short-term grab sample to be representative of the air quality at a site.

- Remote Optical Sensing

This technique, also referred to as long-path or open-path monitoring, involves transmitting either an infrared or ultraviolet light beam across a long open path and measuring the absorbance at specific wavelengths. The technique is capable of analyzing any preselected organic or inorganic volatile compound that can be resolved from compounds naturally occurring in ambient air. Current projected removal applications include perimeter monitoring during site cleanups and measurement of emission source strengths during site assessments.

- TAGA Direct Air Sampling Mass Spectrometer/Mass Spectrometer

The Trace Atmospheric Gas Analyzer (TAGA), which is operated by the U.S. EPA/ERT, is capable of real-time detection of preselected organic compounds at low parts-per-billion concentrations. The instrument has been successfully used by the U.S. EPA/ERT for isolating individual emission plumes and tracking those plumes back to their sources.

APPENDIX B

Air Sampling Equipment and Media/Devices

AIR SAMPLING EQUIPMENT

- High-Volume, Total Suspended Particulate (TSP) Samplers

High-volume TSP samplers collect all suspended particles by drawing air across an 8- by 10-inch glass-quartz filter. The sample rate is adjusted to 40 cubic feet per minute (CFM), or 1134 liters per minute (L/min), and it is held constant by a flow controller over the sample period. The mass of TSPs can be determined by weighing the filter before and after sampling. The composition of the filter varies according to the analytical method and the detection limit required.

- PM-10 Samplers

PM-10 samplers collect particulates with a diameter of 10 microns or less from ambient air. Particulates of this size represent the respirable fraction, and thus are of special significance. PM-10 samplers can be high-volume or low-volume. The high-volume sampler operates in the same manner as the TSP sampler at a constant flow rate of 40 CFM; it draws the sample through a special impactor head which collects particulates of 10 microns or less. The particulate is collected on an 8- by 10-inch filter. The low-volume sampler operates at a rate of approximately 17 L/min. The flow must remain constant through the impactor head to maintain the 10-micron cut-off point. The low-volume PM-10 collects the sample on 37-mm Teflon filters.

- High-Volume PS-1 Samplers

High-volume PS-1 samplers draw a sample through polyurethane foam (PUF) or a combination foam and XAD-2 resin plug, and a glass quartz filter at a rate of 5-10 CFM (144 to 282 L/min). This system is

excellent for measuring low concentrations of semivolatiles, PCBs, pesticides, or chlorinated dioxins in ambient air.

- Area Sampling Pumps

These pumps provide flow-rate ranges of 2-20 L/min and have a telescopic sampling mast with the sampling train. Because of the higher volume, this pump is suitable for sampling low concentrations of airborne contaminants (i.e., asbestos sampling). These pumps are also used for metals, pesticides and PAH sampling which require large sample volumes.

- Personal Sampling Pumps

Personal sampling pumps are reliable portable sampling devices that draw air samples through a number of sampling media including resin tubes, impingers, and filters. Flow rates are usually adjustable from 0.1 to 4 L/min (or 0.01 to .75 L/min with a restrictive orifice) and can remain constant for up to 8 hours on one battery charge or continuously with an AC charger/converter.

- Canister Samplers

Evacuated canister sampling systems use the pressure differential between the evacuated canister and ambient pressure to bleed air into the canister. The sample is bled into the canister at a constant rate over the sampling period using a critical orifice, a mechanically compensated regulator, or a mass flow control device until the canister is near atmospheric pressure.

Pressure canister sampling systems use a pump to push air into the canister. To maintain a higher, more controlled flow, the pump typically controls the pressure differential across a critical orifice at the

inlet of the canister, resulting in a pressurized canister at the completion of sampling.

AIR SAMPLING MEDIA/DEVICES

If possible, before employing a specific sampling method, consult the laboratory that will conduct the analyses. Many of the methods can be modified to provide better results or a wider range of results.

- **Summa[®] Canisters**

Summa canisters are highly polished passivated stainless steel cylinders. The Summa polishing process brings chrome and nickel to the surface of the canisters, which results in an inert surface. This surface restricts adsorption or reactions that occur on the canister's inner surface after collection. At the site, the canister is either placed in a sampler to control sample collection rate, or opened to collect a grab sample. Samples can be collected by allowing air to bleed into or be pumped into the canister. U.S. EPA/ERT uses 6-liter Summa canisters for VOC and permanent gas analysis.

- **Passive Dosimeters**

Passive dosimeters are clip-on vapor monitors (samplers) in which the diffused contaminants are absorbed on specially prepared active surfaces. Industrial hygienists commonly use dosimeters to obtain time-weighted averages or concentrations of chemical vapors, as they can trap over 130 organic compounds. Selective dosimeters have also been developed for a number of chemicals including formaldehyde, ethylene oxide, hydrogen sulfide, mercury vapor, nitrogen dioxide, sulfur dioxide, and ozone. Dosimeters must be sent to a laboratory for analysis.

- **Polyurethane Foam (PUF)**

PUF is a sorbent used with a glass filter for the collection of semivolatile organic compounds such as pesticides, PCBs, chlorinated dioxins and furans, and PAHs. Fewer artifacts (chemical changes that occur

to collected compounds) are produced than with some other solid sorbents. PUF is used with the PS-1 sampler and U.S. EPA Method TO13. PUF can also be used with personal sampling pumps when sampling for PAHs using the Lewis/McCloud method. Breakthrough of the more volatile PCBs and PAHs may occur when using PUF.

- **Sampling Bags (Tedlar[®])**

Sampling bags, like canisters, transport air samples to the laboratory for analysis. Samples are generally pumped into the bags, but sometimes a lung system is used, in which a pump creates a vacuum around the bag in a vacuum box. Then the sample flows from a source into the bag. This method is used for VOCs, fixed gases (CO₂, O₂, and N₂) and methane.

- **Impingers**

An impinger allows an air sample to be bubbled through a solution, which collects a specific contaminant by either chemical reaction or absorption. For long sampling periods, the impinger may need to be kept in an ice bath to prevent the solution from evaporating during sampling. The sample is drawn through the impinger by using a sampling pump or more elaborate sampling trains with multiple impingers.

- **Sorbent Tubes/Cartridges**

A variety of sampling media are available in sorbent tubes, which are used primarily for industrial hygiene. A few examples are carbon cartridges, carbon molecular sieves, Tenax tubes and tube containing the XAD-2 polymer. Depending upon the sorbent material, tubes can be analyzed using either a solvent extraction or thermal desorption. The former technique uses standard laboratory equipment and allows for multiple analyses of the same sample. The latter technique requires special, but readily available, laboratory equipment and allows only one analysis per sample. In addition, thermal desorption typically allows for lower detection limits by two or more orders of magnitude. Whenever sorbent tubes are

being used for thermal desorption, they should be certified as "clean" by the laboratory doing the analysis.

Thermally Desorbed Media

During thermal desorption, high-temperature gas streams are used to remove the compounds collected on a sorbent medium. The gas stream is injected and often cryofocused into an analytical instrument, such as a GC, for compound analysis:

- **Tenax Tubes**

Tenax tubes are made from commercially available polymer (p-phenylene oxide) packed in glass or stainless steel tubes through which air samples are drawn or sometimes pumped. These tubes are used in U.S. EPA Method TO1 and VOST for volatile nonpolar organic, some polar organic, and some of the more volatile semivolatile organics. Tenax is not appropriate for many of the highly volatile organics (with vapor pressure greater than approximately 200 mm Hg).

- **Carbonized Polymers**

The carbonized molecular sieve (CMS), a carbonized polymer, is a commercially available, carbon sorbent packed in stainless-steel sampling tubes through which air samples are drawn or sometimes pumped. These are used in U.S. EPA Method TO2 for highly volatile nonpolar compounds which have low-breakthrough volumes on other sorbents. When high-thermal desorption temperatures are used with CMS, more variability in analysis may occur than with other sorbents.

- **Mixed Sorbent Tubes**

Sorbent tubes can contain two type of sorbents. Combining the advantages of each sorbent into one tube increases the possible types of compounds to be sampled. The combination of two sorbents can also reduce the chance that highly volatile compounds will break through the sorbent media. An example of a mixed sorbent tube is the combination of Tenax and charcoal with a

carbonized molecular sieve. A potential problem with mixed sorbent tubes is the breakthrough of a compound from an earlier sorbent to a later sorbent from which it cannot be desorbed.

Solvent-Extracted Media

Solvent-extracted media use the principle of chemical extraction to remove compounds collected on a sorbent media. The chemical solvent is injected into an instrument, such as a GC, for analysis of compounds. Examples of solvent-extracted media follow:

- **Chemically Treated Silica Gel**

Silica gel is a sorbent which can be treated with various chemicals. The chemically treated silica gel can then be used to sample for specific compounds in air. Examples include the DNPH-coated silica gel cartridge used with U.S. EPA Method TO11.

- **XAD-2 Polymers**

XAD-2 polymers usually are placed in tubes, custom-packed sandwich-style with polyurethane foam, and prepared for use with U.S. EPA Method TO13 or the semi-VOST method. The polymers are used for the collection of semivolatile polar and nonpolar organic compounds. The compounds collected on the XAD-2 polymer are chemically extracted for analysis.

- **Charcoal Cartridges**

Charcoal cartridges, consisting of primary and backup sections, trap compounds by adsorption. Ambient air is drawn through them so that the backup section verifies that breakthrough of the analytes on the first section did not occur, and the sample collection was therefore quantitative. Quantitative sample collection is evident by the presence of target chemicals on the first charcoal section and the absence on the second section. Next, the adsorbed compounds must be eluted, usually with a solvent extraction, and analyzed by GC with a detector, such as a Mass Spectrometer (MS).

- Tenax Tubes

Cartridges are used in OSHA and NIOSH methods in a manner similar to charcoal cartridges but typically for less volatile compounds.

Particulate Filters

Particulate filters are used by having a sampling pump pass air through them. The filter collects the particulates present in the air and is then analyzed for particulate mass or chemical or radiological composition. Particulate filters are made from different materials which are described below.

- Mixed Cellulose Ester (MCE)

MCE is manufactured from mixed esters of cellulose which are a blend of nitro-cellulose and cellulose acetate. MCE filters are used often for particulate sampling.

- Glass Fiber

Glass fiber is manufactured from glass fibers without a binder. Particulate filters with glass fiber provide high flow rates, wet strength, and high, solid holding capacity. Generally, the filters are used for gravimetric analysis of particulates.

- Polyvinyl Chloride

Particulate filters with polyvinyl chloride are resistant to concentrated acids and alkalis. Their low moisture pickup and light tare weight make them ideal for gravimetric analysis.

- Teflon

Teflon is manufactured from polytetrafluorethylene (PTFE). Particulate filters with Teflon are easy to handle and exceptionally durable. Teflon filters are used for metal collection.

- Silver

Particulate filters manufactured from pure silver have high collection efficiency and uniform pore size. These filters are used for mercury collection and analysis.

- Cellulose

Particulate filters with cellulose contain less than 0.01% ash. These filters are used to collect particulates.

Appendix F

Surface Soil Sampling (CDM Federal SOP 1-3, Revision 4)

SURFACE SOIL SAMPLING

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Prepared: Del Baird

Technical Review: Brian Jerks

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Approved: [Signature]

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Issued: Rosemary J. Austin 6/20/01

Signature/Date

1.0 OBJECTIVE

The objective of this standard operating procedure (SOP) is to define the techniques and the requirements for collecting surface soil samples.

2.0 BACKGROUND

Surface soils are generally defined as the soils extending from ground surface to approximately 1 foot below ground surface (bgs). Surface soil samples are frequently collected from 0 to 6 inches bgs. The techniques and protocol described herein may be used to collect other surface media, including sediment and sludge.

2.1 Definitions

Surface Soil - The soil that exists down from the surface approximately one foot (30 centimeters). Depending on application, the soil interval to be sampled will vary.

Grab Sample - A discrete portion or aliquot taken from a specific location at a given point in time.

Composite - Two or more sub-samples taken from a specific media and site at a specific point in time. The sub-samples are collected and mixed, then a single average sample is taken from the mixture.

Spoon/Scoop - A small stainless steel or Teflon® utensil approximately 6 inches in length with a stem-like handle.

Trowel - A small stainless steel or Teflon® shovel approximately 6 to 8 inches in length with a slight (approximately 140°) curve across. The trowel has a stem-like handle (for hand operation). Samples are collected with a spooning action.

2.2 Discussion

Surface soil samples are collected to determine the type(s) and level(s) of contamination and are often important to risk assessment. These samples may be collected as part of an investigative plan, site-specific sampling plan, and/or as a screen for "hot spots," which may require more extensive sampling.

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Sediment(s) and sludge(s) that have been exposed by evaporation, stream rerouting, or any other means are collected by the same methods as those for surface soil(s). Typically, the top 1 to 2 centimeters (cm) of material, including vegetation, are carefully removed before collection of the sample.

Surface soil and exposed sediment or sludge are collected using stainless steel and/or Teflon®-lined trowels or scoops.

2.3 Associated Procedures

- CDM Federal SOP 1-2, Sample Custody
- CDM Federal SOP 2-1, Packaging and Shipping of Environmental Samples
- CDM Federal SOP 4-1, Field Logbook Content and Control
- CDM Federal SOP 4-5, Field Equipment Decontamination at Non-radioactive Sites

3.0 RESPONSIBILITIES

Site Manager - The site manager is responsible for ensuring that sampling efforts are conducted in accordance with this procedure and any other SOPs pertaining to specific media sampling.

Field Team Leader - The field team leader is responsible for ensuring that field personnel collect surface soil samples in accordance with this and other relevant procedures.

4.0 REQUIRED EQUIPMENT

- Insulated cooler and waterproof sealing tape
- Ice bags or "blue ice"
- Latex or appropriate gloves
- Plastic zip-top bags
- Personal protective clothing and equipment
- Stainless steel and/or Teflon®-lined spatulas and pans, trays, or bowls
- Stainless steel and/or Teflon®-lined trowels or spoons (or equipment as specified in the site-specific plans)
- Plastic sheeting
- Project plans (work plan/health and safety plan)
- Appropriate sample containers
- Field logbook
- Indelible ink pen and/or marker
- Sample chain-of-custody forms
- Custody seals
- Decontamination supplies

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Additional equipment is discussed in Section 5.2.2, VOC Field Sampling/Preservation Methods.

5.0 PROCEDURES

5.1 Preparation

The following steps must be followed when preparing for sample collection:

1. Don the appropriate personal protective clothing as dictated by the site-specific health and safety plan.
2. Locate sampling location(s) in accordance with project documents (e.g., work plan) and document pertinent information in the appropriate field logbook.
3. Processes for verifying depth of sampling must be specified in the site-specific plans.
4. Place clean plastic sheeting on a flat, level surface near the sampling area, if possible, and place equipment to be used on the plastic; place the insulated cooler(s) on separate plastic sheeting. Cover all equipment and supplies with clean plastic sheeting when not in use.
5. A clean, decontaminated trowel, scoop, or spoon will be used for each sample collected. Other equipment may be used (e.g., shovels) if constructed of stainless steel.

5.2 Collection

The following general steps must be followed when collecting surface soil samples:

1. Surface soil samples are normally collected from the least contaminated to the most-contaminated areas.
2. Document the sampling events, recording the information in the designated field logbook. Document any and all deviations from SOPs in the field logbook and include rationale for changes. See CDM Federal SOP 4-1.
3. Carefully remove stones, vegetation, snow, etc. from the ground surface in the immediate vicinity of the sampling location.
4. First collect required sample aliquot for volatile analyses as well as any other samples that would be degraded by aeration. Follow with collection of samples for other analyses.
5. Decontaminate sampling equipment between locations. See CDM Federal SOP 4-5.

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5.2.1 Method for Collecting Samples for Volatile Organic Compound (VOC) Analysis

The requirements for collecting grab samples of surface soil for VOCs or other samples degraded by aeration are as follows:

1. VOC samples shall be collected with the least disturbance possible.
2. VOC samples shall be collected as grab samples; however, the method of collection will vary from site to site, based on data quality objectives and the degree of known or suspected contamination.
3. Complete sample label by filling in the appropriate information and securing the label to the container. Cover the sample label with a piece of clear tape.
4. Use a clean stainless steel or Teflon®-lined trowel or spoon (or tube) to collect sufficient material in one grab to fill the sample containers.
5. With the aid of a clean stainless steel spatula, quickly fill the sample containers directly from the sampling device, removing stones, twigs, grass, etc., from the sample. Fill the containers as full and compact as possible to minimize headspace.
6. Immediately secure the Teflon®-lined cap(s) on the sample container(s).
7. Wipe the containers with a clean Kimwipe or paper towel to remove any residual soil from the exterior of the container.
8. Place the containers in individual zip-top plastic bag(s) and seal the bag(s).
9. Pack all samples as required. Include properly completed documentation, and affix signed and dated custody seals to the cooler lid.

NOTE: A trip blank should be included with sample coolers containing VOC samples. QA sample requirements vary from project to project. Consult the project-specific work plan for requirements.

5.2.2 Field Sampling/Preservation Methods

The following four sections contain SW 846 methods for sampling and field preservation. These methods include EN CORE™ Sampler Method for low-level detection limits, EN CORE™ Sampler Method for high level/detection limits/screening, acid preservation, and methanol preservation. These methods are very detailed and contain equipment requirements at the beginning of each section.

NOTE: Some variations from these methods may be required depending on the contracted analytical laboratory, such as sample volume.

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5.2.2.1 EN CORE™ SAMPLER COLLECTION FOR LOW LEVEL ANALYSES (≥ 1 UG/KG)

EN CORE™ Sampling Equipment Requirements

The following equipment is required for low-level analysis:

- Three 5-g samplers

NOTE: The sample volume requirements are general requirements. Actual sample volumes, sizes, and quantities may vary depending on client or laboratory requirements.

- One 4-ounce widemouth glass jar or applicable container for moisture analysis
- One T-handle
- Paper towels

EN CORE™ Sampling Steps for Low Level Analysis

1. Remove sampler and cap from package and attach T-handle to sampler body.
2. Quickly push the sampler into a freshly exposed surface of soil until the O-ring is visible within the hole on the side of the T-handle. If the O-ring is not visible within this window, then the sampler is not full.
3. Extract the sampler and wipe the sampler head with a paper towel so that the cap can be tightly attached.
4. Push cap on with a twisting motion to secure to the sampler body.
5. Rotate the sampler stem counterclockwise until stem locks in place to retain sample within the sampler body.
6. Fill out sample label and attach to sampler.
7. Repeat procedure for the other two samplers.
8. Collect moisture sample in 4-ounce widemouth jar using a clean stainless steel spoon or trowel.
9. Store samplers at 4° Celsius. Samples must be shipped and delivered to the analytical laboratory for extraction within 48 hours.

NOTE: Verify state requirements for extraction/holding times.

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5.2.2.2 ACID PRESERVATION SAMPLING FOR LOW LEVEL ANALYSES (≤ 1 UG/KG)

Acid Preservation Sampling Equipment Requirements

The following equipment and supplies are required if field acid preservation is required:

- One 40mL VOA vial with acid preservation (for field testing of soil pH)
- Two pre-weighed 40mL VOA vials with acid preservative and stir bar (for lab analysis)
- Two pre-weighed 40mL VOA vials with water and stir bar (in case samples cannot be pre-preserved)
- One pre-weighed jar that contains methanol or a pre-weighed empty jar accompanied with a pre-weighed vial that contains methanol (for screening sample and/or high level analysis)
- One 4-oz widemouth glass jar or applicable container for moisture analysis
- One 2-oz jar with acid preservative (in case additional acid is needed due to high soil pH)
- One appropriately sized scoop capable of delivering 1g of solid sodium bisulfate
- pH paper
- Weighing scale capable of reading to 0.01g
- Set of balance weights used in daily balance calibration
- Gloves for working with pre-weighed sample vials
- Paper towels
- Sodium bisulfate acid (NaHSO_4)
- A cutoff plastic syringe or other coring device capable of collecting sufficient sample volume (5g)

Testing Effervescing Capacity of Soils

Soils must be tested with acid to determine the amount of effervescing that will occur when preserved with acid. Effervescing will drive off VOCs as well as create a high pressure in a sealed vial that could result in the explosion of the sample container. The following steps provide information on the effervescing capacity of the soil.

1. Place approximately 5g of soil into a vial that contains acid preservative and no stir bar.
2. Do not cap this vial as it may EXPLODE upon interaction with the soil.
3. Observe the sample for gas formation (due to carbonates in the soil).
4. If vigorous or sustained gas emissions are observed, then acid preservation is not acceptable to preserve the sample.
 - In this case the samples need to be collected in the VOA vials with only water and a stir bar. The vials with acid preservative CANNOT be used.

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5. If a small amount or no gas formation occurs, then acid preservation is acceptable to preserve the sample. Keep this testing vial for use in the buffering test detailed below.

- In this case the samples need to be collected in the VOA vials with the acid preservative and a stir bar.

Testing Buffering Capacity of Soils

The soils must be tested to determine the quantity of acid that is required to achieve a pH reading of ≤ 2 standard units (STUs). The following steps will assist in determining this quantity.

1. If acid preservation is acceptable for sampling soils, then the sample vial that was used to test the effervescing capacity of the soils can be used to test the buffering capacity.
2. Cap the vial that contains 5g of soil, acid preservative, and no stir bar from Step 1 in the effervescing test.
3. Shake the vial gently to homogenize the contents.
4. Open the vial and check the pH of the acid solution with pH paper.
 - If the pH paper reads below 2, then the sampling can be done in the two pre-weighed 40mL VOA vials with the acid preservative and stir bar. Since the pH was below 2, it is not necessary to add additional acid to the vials.
 - If the pH paper reads above 2, then additional acid needs to be added to the sample vial.
5. Use the jar with the solid sodium bisulfate acid and add another 1g of acid to the sample.
6. Cap the vial and shake thoroughly again.
7. Repeat Step 4.
 - If the pH paper reads below 2, then the sampling can be done in the two pre-weighed 40mL VOA vials with the acid preservative and stir bar and one extra gram of acid.
 - Make a note of the extra gram of acid needed so the same amount of acid can be added to the vials the lab will analyze.
 - If the pH paper reads above 2, repeat Steps 5 through 7 until the sample pH ≤ 2 STUs.

Now that the soil chemistry has been determined, the actual sampling can occur. The procedure stated below assumes the correct vials are used based on the guidance discussed.

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Sample Preservation Steps

1. Wear gloves during all handling of pre-weighed vials.
2. Add more acid if necessary (based on the buffering capacity testing discussed in the previous section).
3. Quickly collect a 5g sample using a cut off plastic syringe or other coring device designed to deliver 5g of soil from a freshly exposed surface of soil.
4. Carefully wipe exterior of sample collection device with a clean paper towel.
5. Quickly transfer the sample to the appropriate VOA vial, use caution when extruding the sample to prevent splashing of the acid in the vial.
6. Remove any soil from the threads of the sample vial using a clean paper towel.
7. Cap vial and weigh the jar to the nearest 0.01g.
8. Record exact weight on sample label.
9. Repeat sampling procedure for the duplicate VOA vial.
10. Weigh the vial containing methanol preservative in it to the nearest 0.01g. If the weight of the vial with methanol varies by more than 0.01g from the original weight recorded on the vial, discard the vial. If the weight is within tolerance, it can be used for soil preservation below.
11. Take the empty jar or the jar that contains the methanol preservative.
12. Quickly collect a 25g or 5g sample using a cut off plastic syringe or other coring device designed to deliver 25g or 5g of soil from a freshly exposed surface of soil. The 25g or 5g size is dependent on who is doing the sampling and requirements specified by the analytical laboratory.
13. Carefully wipe the exterior of the collection device with a clean paper towel.
14. Quickly transfer the soil to an empty jar or a jar that contains methanol. If extruding into a jar that contains methanol, be careful not to splash the methanol outside of the vial.
15. If the jar used to collect the soil plug was empty before the soil was added, immediately preserve with the methanol provided, using only one vial of methanol preservative per sample jar.

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16. Remove any soil from the threads of the sample vial using a clean paper towel and cap the jar.
17. Weigh the jar with sample to the nearest 0.01g and record the weight on the sample label.
18. Collect dry weight sample using a clean stainless steel spoon or trowel.
19. Store samples at 4° Celsius.
20. Ship sample containers to the analytical laboratory with plenty of ice in accordance with Department of Transportation (DOT) regulations (CORROSIVE. FLAMMABLE LIQUID. POISON).

5.2.2.3 EN CORE™ SAMPLER COLLECTION FOR HIGH LEVEL ANALYSES (≥200 UG/KG)

EN CORE™ Sampling Equipment Requirements

The following equipment is required for high-level analysis.

- One 25-g sampler or one 5-g sampler

NOTE: The volume requirements specified are general requirements. Actual sample volumes, container sizes, and quantities may vary depending on client or laboratory requirements.

- One 4-oz widemouth glass jar of applicable container specified for moisture analysis
- One T-handle
- Paper towels

EN CORE™ Sampling Steps for High Level Analysis

1. Remove sample and cap from package and attach T-handle to sampler body.
2. Quickly push the sampler into freshly exposed surface of soil until the O-ring is visible within the hole/window on the side of the T-handle. If the O-ring is not visible within the window/hole, then the sampler is not full.
3. Use a clean paper towel to quickly wipe the sampler head so that the cap can be tightly attached.
4. Push cap on with a twisting motion to secure to the sampler body.
5. Fill out sample label and attach to sampler.

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6. Rotate sampler stem counterclockwise until the stemlocks in place to retain the sample within the sampler body.
7. Collect moisture sample in 4-oz widemouth glass jar or designated container using a clean stainless steel spoon or trowel.
8. Store samplers at 4° Celsius. Samples must be shipped and delivered to the analytical laboratory for extraction within 48 hours.

NOTE: Verify state requirements for extraction/holding times.

5.2.2.4 METHANOL PRESERVATION SAMPLING FOR HIGH LEVEL ANALYSES (≥ 200 UG/KG)

Methanol Preservation Sampling Equipment Requirements

- One pre-weighed jar that contains methanol or a pre-weighed empty jar accompanied with a pre-weighed vial that contains methanol (laboratory grade)
- One dry weight cup
- Weighing balance that accurately weighs to 0.01g
- Set of balance weights used in daily balance calibration
- Latex gloves
- Paper towels
- Cutoff plastic syringe or other coring device to deliver 5g or 25g of soil

Sampling Preservation Steps

1. Wear gloves during all handling of pre-weighed vials.
2. Weigh the vial containing methanol preservative in it to the nearest 0.01g. If the weight of the vial with methanol varies by more than 0.01g from the original weight recorded on the vial, discard the vial. If the weight is within tolerance, it can be used for soil preservation/ collection below.
3. Take the empty jar or the jar that contains the methanol preservative.
4. Quickly collect a 25g or 5g sample using a cut off plastic syringe or other coring device designed to deliver 25g or 5g of soil from a freshly exposed surface of soil.
5. Carefully wipe the exterior of the collection device with a clean paper towel.

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6. Quickly transfer the soil to an empty jar or a jar that contains methanol. If extruding into a jar that contains methanol, be careful not to splash the methanol outside of the vial. Again, the type of jar used is dependent on who is doing the laboratory analysis.
7. If the jar used to collect the soil plug was empty before the soil was added, immediately preserve with the methanol provided, using only one vial of methanol preservative per sample jar.
8. Remove any soil from the exterior of the vial using a clean paper towel and cap the sample jar.
9. Weigh the jar with the soil in it to the nearest 0.01g and record the weight on the sample label.
10. Collect dry weight sample using a clean stainless steel spoon or trowel.
11. Store samples at 4° Celsius.
12. Ship sample containers with plenty of ice to the analytical laboratory in accordance with DOT regulations (CORROSIVE. FLAMMABLE LIQUID. POISON).

5.2.3 Method for Collecting Samples for Nonvolatile Organic or Inorganic Compound Analysis

The requirements for collecting samples of surface soil for nonvolatile organic or inorganic analyses are as follows:

1. Label each sample container with the appropriate information. Secure the label by covering it with a piece of clear tape.
2. Use a decontaminated stainless steel or Teflon®-lined trowel or spoon to obtain sufficient sample from the required interval and sub-sampling points, if necessary, to fill the specified sample containers.
3. Empty the contents of each fill of the sampling device directly into a clean stainless steel or Teflon®-lined tray or bowl.
4. Homogenize the sample by mixing with a spoon, spatula, or trowel.
5. Use the spoon, spatula, or trowel to distribute the uniform mixture into the labeled sample containers. Fill organic sample containers first, then inorganics.
6. Secure the appropriate cap on each container immediately after filling it.
7. Wipe the sample containers with a clean Kimwipe or paper towel to remove any residual soil.

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8. Place sample containers in individual zip-top plastic bags and seal the bags.
9. Pack all samples as required. Include properly completed documentation, and affix custody seals to the cooler lid.
10. Decontaminate sampling equipment according to CDM Federal SOP 4-5.

6.0 RESTRICTIONS/LIMITATIONS

When grab sampling for VOC analysis or for analysis of any other compound(s) that may be degraded by aeration, it is necessary to minimize sample disturbance and, hence, analyze loss. The representativeness of this sample is difficult to determine because the collected sample represents a single point, is not homogenized, and has been disturbed.

7.0 REFERENCES

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U.S. Environmental Protection Agency, *Test Methods for Evaluating Solid Waste*, Physical/Chemical Methods (SW-846), Third Edition, November 1986, (as amended by Update III, June 1997). Method 5035: Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples.

Appendix G

Field Logbook Content and Control (CDM Federal SOP 4-1, Revision 4)

FIELD LOGBOOK CONTENT AND CONTROL

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Prepared: Del Baird

Technical Review: Larry Davidson

QA Review: David O. Johnson

Approved: [Signature]

Signature/Date

Issued: [Signature]

Signature/Date

1.0 OBJECTIVE

The objective of this standard operating procedure (SOP) is to set CDM Federal criteria for content entry and form of field logbooks. Field logbooks are an essential tool to document field activities for historical and legal purposes.

2.0 BACKGROUND

2.1 Definitions

Biota - The flora and fauna of a region.

Magnetic Declination Corrections - Compass adjustments to correct for the angle between magnetic north and geographical meridians.

2.2 Discussion

Information recorded in field logbooks includes field team names, observations, data, calculations, date/time, weather, and description of the data collection activity, methods, instruments, and results. Additionally, the logbook may contain deviations from plans and descriptions of wastes, biota, geologic material, and site features including sketches, maps, or drawings as appropriate.

3.0 RESPONSIBILITIES

Field Team Leader (FTL) - The FTL is responsible for ensuring that the format and content of data entries are in accordance with this procedure.

Site Personnel - All CDM Federal employees who make entries in field logbooks during onsite activities are required to read this procedure prior to engaging in this activity. The FTL will assign field logbooks to site personnel who will be responsible for their care and maintenance. Site personnel will return field logbooks to the records file at the end of the assignment.

FIELD LOGBOOK CONTENT AND CONTROL

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4.0 REQUIRED EQUIPMENT

- Site-specific plans
- Field notebook
- Indelible black or blue ink pen
- Ruler or similar scale

5.0 PROCEDURES

5.1 Preparation

In addition to this SOP, site personnel responsible for maintaining logbooks must be familiar with all procedures applicable to the field activity being performed. These procedures should be consulted as necessary to obtain specific information about equipment and supplies, health and safety, sample collection, packaging, decontamination, and documentation. These procedures should be located at the field office.

Field logbooks shall be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the logbook. Prior to use in the field, each logbook will be marked with a specific document control number issued by the document control administrator, if required by the contract quality implementation plan (QIP). Not all contracts require document control numbers. The following information shall be recorded on the cover of the logbook:

- Field logbook document control number.
- Activity (if the logbook is to be activity-specific) and location.
- Name of CDM Federal contact and phone number(s).
- Start date.
- In specific cases, special logbooks may be required (e.g., waterproof paper for storm water monitoring).

The first few (approximately five) pages of the logbook will be reserved for a table of contents (TOC). Mark the first page with the heading and enter the following:

TABLE OF CONTENTS

Date/Description	Page
(Start Date)/Reserved for TOC	1-5

The remaining pages of the table of contents will be designated as such with "TOC" written on the top center of each page.

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5.2 Operation

The following is a list of requirements that must be followed when using a logbook:

- Record work, observations, quantities of materials, calculations, drawings, and related information directly in the logbook. If data collection forms are specified by an activity-specific plan, this information need not be duplicated in the logbook. However, any forms used to record site information must be referenced in the logbook.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Do not erase or blot out any entry at any time. Indicate any deletion by a single line through the material to be deleted. Initial and date each deletion. Take care to not obliterate what was written previously.
- Do not remove any pages from the book.

Specific requirements for field logbook entries include:

- Initial and date each page.
- Sign and date the final page of entries for each day.
- Initial and date all changes.
- Multiple authors must sign out the logbook by inserting the following:

Above notes authored by:

- (Sign name)
- (Print name)
- (Date)

- A new author must sign and print his/her name before additional entries are made.
- Draw a diagonal line through the remainder of the final page at the end of the day.
- Record the following information on a daily basis:
 - Date and time
 - Name of individual making entry
 - Names of field team and other persons on site
 - Description of activity being conducted including station or location (i.e., well, boring, sampling location number) if appropriate
 - Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction, and speed) and other pertinent data
 - Level of personal protection to be used
 - Serial numbers of instruments
 - Required calibration information
 - Serial/tracking numbers on documentation (e.g., carrier air bills)

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Entries into the field logbook shall be preceded with the time (written in military units) of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. All measurements made and samples collected must be recorded unless they are documented by automatic methods (e.g., data logger) or on a separate form required by an operating procedure. In these cases, the logbook must reference the automatic data record or form.

At each station where a sample is collected or an observation or measurement made, a detailed description of the location of the station is required. Use a compass (include a reference to magnetic declination corrections), scale, or nearby survey markers, as appropriate. A sketch of station location may be warranted. All maps or sketches made in the logbook should have descriptions of the features shown and a direction indicator. It is preferred that maps and sketches be oriented so that north is toward the top of the page. Maps, sketches, figures, or data that will not fit on a logbook page should be referenced and attached to the logbook to prevent separation.

Other events and observations that should be recorded include:

- Changes in weather that impact field activities.
- Deviations from procedures outlined in any governing documents. Also record the reason for any noted deviation.
- Problems, downtime, or delays.
- Upgrade or downgrade of personal protection equipment.

5.3 Post-Operation

To guard against loss of data due to damage or disappearance of logbooks, completed pages shall be periodically photocopied (weekly, at a minimum) and forwarded to the field or project office. Other field records shall be photocopied and submitted regularly and as promptly as possible to the office. When possible, electronic media such as disks and tapes should be copied and forwarded to the project office.

At the conclusion of each activity or phase of site work, the individual responsible for the logbook will ensure that all entries have been appropriately signed and dated, and that corrections were made properly (single lines drawn through incorrect information, then initialed and dated). The completed logbook shall be submitted to the records file.

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6.0 RESTRICTIONS/LIMITATIONS

Field logbooks constitute the official record of onsite technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by CDM Federal personnel and their subcontractors. They are documents that may be used in court to indicate dates, personnel, procedures, and techniques employed during site activities. Entries made in these notebooks should be factual, clear, precise, and non-subjective. Field logbooks, and entries within, are not to be utilized for personal use.

7.0 REFERENCES

Sandia National Laboratories, *Procedure for Preparing, Sampling and Analysis Plan, Site-Specific Sampling Plan, and Field Operating Procedures*, QA-02-03, Albuquerque Environmental Program Department 3220, Albuquerque, New Mexico, 1991.

Sandia National Laboratories, Division 7723, *Field Operation Procedure for Field Logbook Content and Control*, Environmental Restoration Department, Albuquerque, New Mexico, 1992.

Appendix H

Sample Custody
(CDM Federal SOP 1-2, Revision 3)

SAMPLE CUSTODY

SOP 1-2

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Date October 12, 2001

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Prepared: David O. Johnson

Technical Review: Jackie Mosher

QA Review: Doug Updike

Approved: [Signature]

Signature/Date

Issued: Rosemary Justin 10/12/01
Signature/Date

1.0 OBJECTIVE

Due to the evidentiary nature of samples collected during environmental investigations, possession must be traceable from the time the samples are collected until their derived data are introduced as evidence in legal proceedings. To maintain and document sample possession, sample custody procedures are followed. All paperwork associated with the sample custody procedures will be retained in CDM Federal Programs Corporation (CDM Federal) files unless the client requests that it be transferred to them for use in legal proceedings or at the completion of the contract.

Note: Sample custody documentation requirements vary with the specific EPA region or client. This SOP is intended to present basic sample custody requirements, along with common options. Specific sample custody requirements should be presented in the project-specific quality assurance (QA) project plan or project-specific modification or clarification form (See Section U-1).

2.0 BACKGROUND

2.1 Definitions

Sample – A sample is material to be analyzed that is contained in single or multiple containers representing a unique sample identification number.

Sample Custody – A sample is under custody if:

1. It is in your possession.
2. It is in your view, after being in your possession.
3. It was in your possession and you locked it up.
4. It is in a designated secure area.

Chain-of-Custody Record – A chain-of-custody record is a form used to document the transfer of custody of samples from one individual to another.

Custody Seal - A custody seal is a tape-like seal that is part of the chain-of-custody process and is used to detect tampering with samples after they have been packed for shipping.

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Sample Label – A sample label is an adhesive label placed on sample containers to designate a sample identification number and other sampling information.

Sample Tag – A sample tag is attached with string to a sample container to designate a sample identification number and other sampling information. Tags may be used when it is difficult to physically place adhesive labels on the container (e.g., in the case of small air sampling tubes).

3.0 RESPONSIBILITIES

Sampler – The sampler is personally responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

Field Team Leader (FTL) – The FTL is responsible for ensuring that strict chain-of-custody procedures are maintained during all sampling events. The FTL is also responsible for coordinating with the subcontractor laboratory to ensure that adequate information is recorded on custody records. The FTL determines whether proper custody procedures were followed during the fieldwork and decides if additional samples are required.

Field Sample Custodian – The field sample custodian, when designated by the FTL, is responsible for accepting custody of samples from the sampler(s) and properly packing and shipping the samples to the laboratory assigned to do the analyses. A field sample custodian is typically designated only for large and complex field efforts.

4.0 REQUIRED SUPPLIES

- Chain-of-custody records (applicable client or CDM Federal forms)
- Custody seals
- Sample labels or tags
- Clear tape

5.0 PROCEDURES

5.1 Chain-of-Custody Record

This procedure establishes a method for maintaining custody of samples through use of a chain-of-custody record. This procedure will be followed for all samples collected or split samples accepted.

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Field Custody

1. Collect only the number of samples needed to represent the media being sampled. To the extent possible, determine the quantity and types of samples and sample locations prior to the actual fieldwork. As few people as possible should handle samples.
2. Complete sample labels or tags for each sample, using waterproof ink.

Transfer of Custody and Shipment

1. Complete a chain-of-custody record for all samples (see Figure 1 for an example of a chain-of-custody record. Similar forms may be used when requested by the client). When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents sample custody transfer from the sampler, often through another person, to the sample custodian in the appropriate laboratory.
 - The date/time will be the same for both signatures when custody is transferred directly to another person. When samples are shipped via common carrier (e.g., Federal Express), the date/time will not be the same for both signatures. Common carriers are not required to sign the chain-of-custody record.
 - In all cases, it must be readily apparent that the person who received custody is the same person who relinquished custody to the next custodian.
 - If samples are left unattended or a person refuses to sign, this must be documented and explained on the chain-of-custody record.

NOTE: If a field sample custodian has been designated, he/she may initiate the chain-of-custody record, sign and date as the relinquisher. The individual sampler(s) must sign in the appropriate block, but does (do) not need to sign and date as a relinquisher (refer to Figure 1).

2. Package samples properly for shipment and dispatch to the appropriate laboratory for analysis. Each shipment must be accompanied with a separate chain-of-custody record.
3. Include a chain-of-custody record identifying its content in all shipments (refer to Figure 1). The original record will accompany the shipment, and the copies will be retained by the FTL and, if applicable, distributed to the appropriate sample coordinators. Freight bills will also be retained by the FTL as part of the permanent documentation.

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Figure 1
EXAMPLE CDM Federal Chain-of-Custody Record

CDM Federal Programs Corporation
A subsidiary of Camp Dresser & McKee Inc.

125 Maiden Lane, 5th Floor
New York, NY 10038
(212) 785-9123
Fax: (212) 785-6114

CHAIN OF CUSTODY RECORD

PROJECT ID.		FIELD TEAM LEADER		LABORATORY AND ADDRESS				DATE SHIPPED				
PROJECT NAME/LOCATION				LAB CONTRACT:				AIRBILL NO.				
MEDIA TYPE		PRESERVATIVES		SAMPLE TYPE		ANALYSES (List no. of containers submitted)						
1. Surface Water 2. Groundwater 3. Leachate 4. Field QC 5. Soil/Sediment 6. Oil 7. Waste 8. Other _____		1. HCl, pH <2 2. HNO ₃ , pH <2 3. NaOH, pH >12 4. H ₂ SO ₄ , pH <2 5. Zinc Acetate, pH >9 6. Ice Only 7. Not Preserved 8. Other _____		G = Grab C = Composite								
SAMPLE LOCATION NO.	LABORATORY SAMPLE NUMBER	PRESERVATIVES ADDED	MEDIA TYPE	SAMPLE TYPE	19__	TIME	DATE	SAMPLED	REMARKS (Note 1 MS/MSD)			
1.												
2.												
3.												
4.												
5.												
6.												
7.												
8.												
9.												
10.												

SAMPLER SIGNATURES:							
RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME
(SIGN)		(SIGN)		(SIGN)		(SIGN)	
RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME
(SIGN)		(SIGN)		(SIGN)		(SIGN)	
COMMENTS:							

DISTRIBUTION: White and yellow copies accompany sample shipment to laboratory; yellow copy retained by laboratory. Pink copy retained by samplers.

1/98

NOTE: If requested by the client, different chain-of-custody records may be used. Copies of the template for this record may be obtained from the Fairfax Graphics Department.

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Procedure for Completing CDM Federal Example Chain-of-Custody Record (Refer to Figure 1.)

The following procedure is to be used to fill out the CDM Federal chain-of-custody record. The record is provided herein as an example chain-of-custody record. If another type of custody record (i.e., provided by the EPA contract laboratory program or a subcontract laboratory) is used to track the custody of samples, the custody record should be filled out in its entirety.

1. Record project number.
2. Record FTL for the project (if a field sample custodian has been designated, also record this name in the "Remarks" box).
3. Record the name and address of the laboratory to which samples are being shipped.
4. Enter the project name/location or code number.
5. Record overnight courier's airbill number.
6. Record sample location number.
7. Record sample number.
8. Note preservatives type and reference number.
9. Note media type (matrix) and reference number.
10. Note sample type.
11. Enter date of sample collection.
12. Enter time of sample collection in military time.
13. When required by the client, enter the names or initials of the samplers next to the sample location number of the sample they collected.
14. List parameters for analysis and the number of containers submitted for each analysis.
15. Enter MS/MSD (matrix spike/matrix spike duplicate) if sample is for laboratory quality control or other remarks (e.g. sample depth).
16. Sign the chain-of-custody record(s) in the space provided. All samplers must sign each record.
17. If sample tags are used, record the sample tag number in the "Remarks" column.
18. Record date shipped.
19. The originator checks information entered in Items 1 through 16 and then signs the top left "Relinquished by" box, prints his/her name, and enters the current date and time (military).

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20. Send the top two copies (usually white and yellow) with the samples to the laboratory; retain the third copy (usually pink) for the project files. Retain additional copies for the project file or distribute as required to the appropriate sample coordinators.
21. The laboratory sample custodian receiving the sample shipment checks the sample label information against the chain-of-custody record. Sample condition is checked and anything unusual is noted under "Remarks" on the chain-of-custody record. The laboratory custodian receiving custody signs in the adjacent "Received by" box and keeps the copy. The white copy is returned to CDM Federal.

5.2 Sample Labels and Tags

Unless the client directs otherwise, sample labels or tags will be used for all samples collected or accepted for CDM Federal projects.

1. Complete one label or tag with the information required by the client for each sample container collected. A typical label or tag would be completed as follows (see Figure 2 for example of sample tag; labels are completed with the equivalent information):
 - Record the project code (i.e., project or task number).
 - Enter the station number (sample number) if applicable.
 - Record the date to indicate the month, day, and year of sample collection.
 - Enter the time (military) of sample collection.
 - Place a check to indicate composite or grab sample.
 - Record the station (sample) location.
 - Sign in the space provided.
 - Place a check next to "yes" or "no" to indicate if a preservative was added.
 - Place a check under "Analyses" next to the parameters for which the sample is to be analyzed. If the desired analysis is not listed, write it in the empty slot. Note: Do not write in the box for "laboratory sample number."
 - Place or write additional relevant information under "Remarks".
2. Place adhesive labels directly on the sample containers. Place clear tape over the label to protect from moisture.
3. Securely attach sample tags to the sample bottle. On 80 oz. amber bottles, the tag string may be looped through the ring style handle and tied. On all other containers, it is recommended that the string be looped around the neck of the bottle, then twisted and re-looped around the neck until the slack in the string is removed.

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Figure 2
EXAMPLE Sample Tag



Designate	Quab	Preservative: Yes <input type="checkbox"/> No <input type="checkbox"/>
	Comp	
Time	Samples (signature)	ANALYSES
		BOD Anions
		Solids (TSS) (TDS) (SS)
		COD, TOC, Nutrients
		Phenolics
		Mercury
		Metals
		Cyanide
		Oil and Grease
		Month/Day/Year
Priority Pollutants		
Volatile Organics		
Pesticides		
Mutagenicity		
Bacteriology		
Station No.	Remarks:	
Project Code	Tag No.	Lab Sample No.
		3-3023215

NOTE: Equivalent sample labels or tags may be used.

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5.3 Custody Seals

Custody seals must be placed on the shipping containers (e.g., picnic cooler) prior to shipment. The seal should be signed and dated by a field team member.

Custody seals may also be placed on individual sample bottles. Check with the client or refer to EPA regional guidelines for direction.

5.4 Sample Shipping

The CDM Federal standard operating procedure listed below defines the requirements for packaging and shipping environmental samples.

- CDM Federal SOP 2-1, Packaging and Shipping of Environmental Samples

6.0 RESTRICTIONS/LIMITATIONS

Check with the EPA region or client for specific guidelines. If no specific guidelines are identified, this procedure should be followed.

For EPA Contract Laboratory Program (CLP) sampling events, combined chain-of-custody/traffic report forms or other EPA-specific records may be used. Refer to regional guidelines for completing these forms.

The EPA FORMS II Lite™ software may be used to customize sample labels and custody records when directed by the client or the CDM Federal project manager.

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7.0 REFERENCES

U.S. Environmental Protection Agency, *EPA Guidance for Quality Assurance Project Plans*, EPA QA/G-5, EPA/600/R-98/018, February 1998, Section B3.

U.S. Environmental Protection Agency, *National Enforcement Investigations Center, Multi-Media Investigation Manual*, EPA-330/9-89-003-R, Revised March 1992, p.85.

U.S. Environmental Protection Agency, *Contract Laboratory Program (CLP), Guidance for Field Samplers*, EPA-540-R-00-003, Draft Final, June 2001, Section 3.2.

U.S. Environmental Protection Agency, *FORMS II Lite™ User's Guide*, March 2001

U.S. Environmental Protection Agency, Region IV, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, May 1996, Section 3.3.

U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plan*, EM 200-1-3, February 2001, Appendix F.

Appendix I

***Project-Specific Guidance Completion
of Field Sample Data Sheets***
(CDM Federal Document CDM-Libby-03, Revision 2)

Project-Specific Guidance Completion of Field Sample Data Sheets (FSDS)

Project: Libby Asbestos Project – Response Action

Project No.: 2603-024

Document No.: CDM-LIBBY-03 Revision 2

Prepared by: Terry Crowell

Date: 11/17/03

Approved by: _____

Project Manager

Date

Technical Reviewer

Date

QA Reviewer

Date

EPA Approval

Date

A field sample data sheet (FSDS) must be completed using the following guidance.

Definitions:

eLASTIC – Electronic Libby Asbestos Sample Tracking Information Center. The onsite Libby property and sample tracking database maintained by CDM.

Owner – (As it appears in eLASTIC). Person who owns a residential property (may or may not be the current occupant), or the person who owns a commercial property.

Sample Coordinator – person responsible for the custody of all field paper work and samples collected.

Field Sample Data Sheet - All Media

Sheet No.: Pre-assigned unique sequential sheet number. Completed by sample coordinator.

Field Logbook No.: The logbook number being used to record information specific to the samples on the FSDS.

Page No.: Page number in logbook on which information regarding the samples on the FSDS is recorded.

Sampling Date: Date samples are collected, in the form DD/MM/YY.

Address: (As it appears in eLASTIC). The address of the property being sampled.

Addresses are to be entered in the following format:

Street number – Direction – Street Name – Street Abbreviation

Where:

Street number = the number of the street address

Direction = the abbreviation of the street direction (N., S., E., or W.), when applicable. Periods are to be used after the street direction abbreviation. This rule does not apply to directions that follow the street name, such as Highway 37 North or Highway 2 West or South.

Street name = correct spelling of the street name

Street abbreviation = when applicable

Examples:

Road – Rd
Avenue – Ave
Extension – Ext
Street – St
Circle – Cr
Place – Pl
Boulevard – Blvd

Examples: 510 N. Mineral Ave
607 E. Cedar St Ext
521 Pipe Creek Rd
2800 Highway 37 North
300 Highway 2 South

Business Name: (As it appears in eLASTIC). If a business is located on the property, record the name. If a business is not located on the property, record NA.

Owner: (As it appears in eLASTIC). Name of the property owner (not necessarily the current occupant).

Land Use: Description of land use on which property is located.

Sampling Team: Company affiliation of sampling team.

Names: Full name of all members of the sampling team.

Index ID: Sample identification (ID) number. Index ID numbers for the response action samples are in the form 2R-####. A set of available numbers is assigned to each sampling team by the sample coordinator.

Location ID: Unique identification number assigned to each sample location with a unique global positioning system (GPS) coordinate. A set of available numbers is assigned to each sampling team by the sample coordinator. For soil samples, location identifications (IDs) are in the form SP-####. For personal or stationary (including clearance) air monitoring samples, location IDs are in the form of AD-#### or BD-#### are assigned to each sampling team by the sample coordinator, where:

AD-#### is a unique number assigned to an address or work area.

BD-#### is a unique number assigned to a building or structure

In the case of lot blanks, AD-000001 is used for the location ID. In the case of field blanks, the AD number of the property where the cassette is opened is used. In the case of exposure monitoring or any other task where sampling is conducted at multiple properties, MA-000001 is used. Location IDs are tracked in the eLASTIC database, which should be used for reference whenever possible.

Sample Group: The sample group for response action samples must be one of the following options:

Alley	Driveway	Garden	Road
Attic	Exposure Monitoring	House	Shed
Barn	Field	Mine	Stockpile
Borrow Source	Flower Pots	Park	Vehicle
Basement	Flowerbed	Parking Lot	Walkway
Blank	Former Flowerbed	Play Area	Yard
Building	Former Garden	Property	
Crawl Space	Garage	Pumphouse	

Location Description: Description of the location where a sample was collected. Examples are: back yard, side yard, driveway, etc. for soil samples; basement, ground floor, second floor, etc. for air samples. If a soil sample is composed of sub-samples collected from more than one location, circle all that apply.

Category: FS = field sample; FB = field blank; LB = lot blank. Circle the applicable response.

The following sections provide instructions for recording media-specific information.

Field Sample Data Sheet - Soil

Matrix Type: Soil confirmation samples will usually be either surface or subsurface samples. If a sample collected is not a surface or subsurface sample, complete the "other" line using an applicable descriptor, such as mining waste, subsurface soil, fill, etc.

Type: Indicate the type of sample collected, grab or composite. If the sample is a composite sample, provide the number of sub-samples collected.

Time: The time of sample collection, in military time.

Top Depth: Top depth of sample, in inches below the ground surface.

Bottom Depth: Bottom depth of sample, in inches below the ground surface.

Field Comments: Any additional information specific to a sample, such as presence/absence of visible vermiculite.

QC (Field Team): Initials of field team member that completes the quality control check of FSDS.

Entered (LFO): Initials of sample coordination team member that enters the applicable FSDS information into eLASTIC.

Entered: Completed by Volpe personnel at time of data entry.

Validated: Completed by Volpe personnel at time of data entry check.

Field Sample Data Sheet – Stationary Air

Matrix Type: Circle whether the air sample was collected indoors or outdoors.

Filter Diameter: Circle the applicable filter diameter. For response action air sampling, cassettes with a 25-millimeter filter diameter will be used.

Pore Size: Circle the applicable pore size. For response action air sampling, phase contrast microscopy (PCM) cassettes with a 0.8-micron pore size filter will be used.

Flow Meter Type: Circle the applicable flow meter used.

Pump ID Number: Record the identification number of the pump used to collect the air sample.

Flow Meter ID Number: Record the identification number of the flow meter used to collect the air sample.

Start and Stop Date: Record the date sampling occurred in the format DD-MM-YY.

Start Time: Record the starting time of each air sample aliquot, in military time.

Start Flow: Record the starting pump flow rate for the air sample collected in Liters per minute (L/min).

Stop Time: Record the stopping time of each air sample aliquot, in military time.

Stop Flow: Record the stopping pump flow rate for the air sample collected in Liters per minute (L/min).

Pump Fault: If the pump faulted during air sample collection, circle Yes. If the pump did not fault during sample collection, circle No.

MET Station onsite: Circle the applicable response, Yes, No, or Not Applicable (NA). For all blanks (lot or field), circle NA.

Sample Type: Circle the applicable response. For the response action stationary air sampling, select one of the following:

- Clear - first clearance sampling event
- 2nd Clear - second clearance sampling event
- 3rd Clear - third clearance sampling event
- NA - used for all blanks

Cassette Lot Number: For lot blanks, the number identifying the lot the cassettes came from in the manufacturing process.

Field Sample Data Sheet – Personal Air

Person Sampled: First and last name of worker being monitored.

SSN: The last 4 digits of the Social Security Number of the worker being monitored.

Task: A brief description of the task being performed by the worker being monitored. Some examples are: vermiculite-containing insulation (VCI) removal, laborer, detail cleaning.

Matrix Type: Circle whether the air sample was collected indoors or outdoors.

Filter Diameter: Circle the applicable filter diameter. For response action air sampling, cassettes with a 25-millimeter filter diameter will be used.

Pore Size: Circle the applicable pore size. For response action air sampling, phase contrast microscopy (PCM) cassettes with a 0.8-micron pore size filter will be used.

Flow Meter Type: Circle the applicable flow meter used.

Pump ID Number: Record the identification number of the pump used to collect the air sample.

Flow Meter ID Number: Record the identification number of the flow meter used to collect the air sample.

Start and Stop Date: Record the date sampling occurred in the format DD-MM-YY.

Start Time: Record the starting time of each air sample aliquot, in military time.

Start Flow: Record the starting pump flow rate for the air sample collected in Liters per minute (L/min).

Stop Time: Record the stopping time of each air sample aliquot, in military time.

Stop Flow: Record the stopping pump flow rate for the air sample collected in Liters per minute (L/min).

Pump Fault: If the pump faulted during sample collection, circle Yes. If the pump did not fault during sample collection, circle No.

MET Station onsite: Circle the applicable response, Yes, No, or Not Applicable (NA). For all blanks (lot or field), circle NA.

Sample Type: Circle the applicable response. For the response action personal air sampling, select one of the following:

TWA – a time-weighted average sample, collected over an 8-hour period or used in conjunction with one or more other personal air samples to constitute monitoring over an average work day

EXC – an excursion sample, collected over a 30-minute period (time may be approximate)

NA – used for all blanks

Cassette Lot Number: For lot blanks, the number identifying the lot the cassettes came from in the manufacturing process.

Appendix J

Site-Specific Standard Operating Procedure for Soil Sample Collection (CDM Federal Document CDM-Libby-05, Revision 1)

Site-Specific Standard Operating Procedure for Soil Sample Collection

SOP No: CDM-LIBBY-05 Revision 1

Project: Libby Asbestos Remedial Investigation - Contaminant Screening Study (CSS)/Remedial Investigation (RI)

Project Number: 3282-137

Prepared by: Thomas E. Cook
Environmental Scientist

4/3/02
Date


Dee A. Warren, Revision 1
Project Scientist

4/17/03
Date

Approved by:


Project Manager

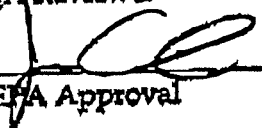
5/3/03
Date


Technical Reviewer

5/7/03
Date


QA Reviewer

5/12/03
Date


EPA Approval

5/19/03
Date

Section 1

Purpose

The purpose of this standard operating procedure (SOP) is to provide a standardized method for surface soil sampling to be used by employees of EPA Region VIII contractors/subcontractors supporting EPA Region VIII CSS and RI activities for the Libby Asbestos Project in Libby, Montana. This SOP describes the equipment and operations used for sampling surface soils in residential areas, which will be submitted for the analysis of Libby amphiboles. The EPA Region VIII remedial project manager, or on-scene coordinator must approve site-specific deviations from the procedures outlined in this document prior to initiation of the sampling activity. This SOP provides the protocols for composite surface-soil sampling.

Section 2

Responsibilities

Successful execution of the sampling and analysis plan (SAP) requires a clear hierarchy of assigned roles with different sets of responsibilities associated with each role.

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Project: 3282-137 - Libby Asbestos Remedial Investigation - SOP: 05-01 and Site Specific Contaminant Sampling SOP Remedial.DOC

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*Project Specific Standard Operating Procedure
Soil Sample Collection*

- Information Field Forms (IFF) - Used to record information such as property detail, location of amphibole contamination, and estimated quantities.
- Field Sample Data Sheet (FSDS) - Used to record soil sample information.
- Permanent marking pen - Used to label sample containers.
- Index ID stickers - Used to label sample containers.
- Plastic buckets - Used to wash nondisposable field equipment between samples.
- Trash bag - Used to dispose gloves and wipes.
- Cooler - Used to store samples while in the field.
- Chain of Custody Record - For ensuring custody of samples until shipping.
- Custody Seals - For ensuring custody of samples during shipping.

Section 4

Sampling Pattern

Each property will be segregated into land use areas for sampling purposes. Use areas may include but not be limited to:

- Yard (grassy area)
- Landscaped area
- Garden
- Fill area
- Driveway

Properties with grassy areas greater than 1/2 acre in size will be sectioned off into separate zones for increased accuracy in characterization. Sectioning properties into additional zones will be at the discretion of the CDM field team leader but consistent among the teams. This segregation will be accomplished so that a five-point composite sample will characterize the section. A five-point composite sample will be collected for land areas less than or equal to 1/8 of an acre.

Up to five composite soil samples will be collected at each property. Composite sampling requires soil collection from multiple (sub-sample) points. Composite samples will be collected from similar land use areas (i.e., yard, garden, stockpiled soil, etc.). Additional composite or grab samples may be collected dependent upon site conditions (i.e., multiple land use areas, zones, etc.). Conversely, not all land areas previously mentioned will be applicable at every property and fewer (not less than two) will be collected.

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Project: PAC-07 - Udry RUCS SAP Revision 1/2004 (Appendix E - SOP Issues and Specific Calculations) Rev: 20P Revision.DOC

*Project Specific Standard Operating Procedure
Soil Sample Collection*

Soil field duplicate samples will be collected at a rate of 1 per 20 (5 percent) of the field samples. Field duplicate samples will be collected as samples co-located in the same land use area. The duplicate will be collected from the same number of subsamples as the parent sample, but the subsample locations of the duplicate sample will be randomly located in the use area. These samples will be independently collected with separate sampling equipment. These samples will be used to determine the variability of sample results in a given land use area. These samples will not be used to determine variability in sampling techniques.

Section 6

Site Cleanup

Specific instruction regarding site cleanup of investigation-derived waste (IDW) is included in CDM SOP 2-2, Guide to Handling Investigation-Derived Waste, with modification. In general, replace soil plug with excess sample volume. The soil should be placed back into the hole and tamped down lightly. If sandy areas such as playgrounds are sampled, refilling the soil plug is not necessary.

Rinse water, the roots of vegetation removed during sampling, and any excess soil volume may be disposed of on the ground as specified in the SAP.

Section 7

Record Keeping and Quality Control

A field logbook should be maintained by each individual or team that is collecting samples as described in the SAP. The SAP will detail specific conditions (SOP 4-1), which require attention, but at a minimum the following information should be collected:

- Date
- Time
- Team members
- Weather conditions
- PPE used
- Locations of any samples and subsamples that could not be acquired
- Descriptions of any deviations to the SAP and the reason for the deviation

Complete the IFF and FSDS for each property/sample.

Quality control samples will include:

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~~Project Specific Standard Operating Procedure - Soil Sample Collection~~

*Project Specific Standard Operating Procedure
Soil Sample Collection*

- Field duplicates
- Equipment blank samples

Detailed information on QC sample collection and frequency is included in the SAP.

Section 8 Decontamination

All sampling equipment must be decontaminated prior to reuse. Specific instructions on sample equipment decontamination are included in CDM SOP 4-5, Field Equipment Decontamination at Nonradioactive Sites, with modification. In general, the procedure to decontaminate all equipment is outlined below:

Decontamination procedures for soil sampling equipment will follow these steps:

- Remove all gross contamination with plastic brush
- Use DI water and a plastic brush to wash each piece of equipment
- Remove excess water present on the equipment by shaking
- Use a paper towel to dry each piece of equipment
- Wrap dried equipment in aluminum foil

Once a week all soil sampling equipment will be cleaning using Alconox and DI water.

Spent wipes, gloves, and PPE must be disposed or stored properly as specified in the SAP.

Section 9 Glossary

Sampling and Analysis Plan (SAP) - The written document that spells out the detailed site-specific procedures to be followed by the project leader and the field personnel.

Sample Point - The actual location at which the sample is taken. The dimension of a sample point is 2 in. across by 1 in. deep (6 in. for disturbed areas).

Composite Sampling - A sample program in which multiple sample points are compiled together and submitted for analysis as a single sample.

Land Use Area - A section of property segregated by how the property owner uses the section. For example, garden landscaped areas are individual land use areas. Grassy areas (i.e., lawn) are also considered to be a separate land use area.

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PROJECT: 04-05-04 - URBAN WASTE SAP Revision 11/2004 Appendix C - SOP Method and Specific Decontamination Steps (SOP Revision 11/2004)

Appendix K

Sampling and Analysis – Non-Mandatory **(U.S. Department of Labor, OSHA 29 CFR 1926.1101 Appendix B)**

**U.S. Department of Labor**
Occupational Safety & Health Administrationwww.osha.govSearch [Advanced Search](#) | [A-Z Index](#)[\[Text Only\]](#)**Regulations (Standards - 29 CFR)****Sampling and Analysis - Non-mandatory - 1926.1101 App B** [Regulations \(Standards - 29 CFR\) - Table of Contents](#)

• Part Number:	1926
• Part Title:	Safety and Health Regulations for Construction
• Subpart:	Z
• Subpart Title:	Toxic and Hazardous Substances
• Standard Number:	1926.1101 App B
• Title:	Sampling and Analysis - Non-mandatory

Matrix

Matrix:**OSHA Permissible Exposure Limits:**

Time Weighted Average.....	0.1 fiber/cc
Excursion Level (30 minutes).....	1.0 fiber/cc

Collection Procedure:

A known volume of air is drawn through a 25-mm diameter cassette containing a mixed-cellulose ester filter. The cassette must be equipped with an electrically conductive 50-mm extension cowl. The sampling time and rate are chosen to give a fiber density of between 100 to 1,300 fibers/mm² on the filter.

Recommended Sampling Rate.....	0.5 to 5.0 liters/ minute (L/min)
--------------------------------	--------------------------------------

Recommended Air Volumes:

Minimum.....	25 L
Maximum.....	2,400 L

Analytical Procedure:

A portion of the sample filter is cleared and prepared for asbestos fiber counting by Phase Contrast Microscopy (PCM) at 400X.

Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources can be substituted.

1. Introduction

This method describes the collection of airborne asbestos fibers using calibrated sampling pumps with mixed-cellulose ester (MCE) filters and analysis by phase contrast microscopy (PCM). Some terms used are unique to this method and are defined below: Asbestos: A term for naturally occurring fibrous minerals. Asbestos includes chrysotile, crocidolite, amosite (cummingtonite-grunerite asbestos), tremolite asbestos, actinolite asbestos, anthophyllite asbestos, and any of these minerals that have been chemically treated and/or altered. The precise chemical formulation of each species will vary with the location from which it was mined. Nominal compositions are listed:

Chrysotile.....	Mg (3) Si (2) O (5) (OH) (4)
Crocidolite.....	Na (2) Fe (3) (2) + Fe (2) (3) + Si (8) O (22) (OH) (2)
Amosite.....	(Mg, Fe) (7) Si (8) O (22) (OH) (2)
Tremolite-actinolite.....	Ca (2) (Mg, Fe) (5) Si (8) O (22) (OH) (2)
Anthophyllite.....	(Mg, Fe) (7) Si (8) O (22) (OH) (2)

Asbestos Fiber: A fiber of asbestos which meets the criteria specified below for a fiber.

Aspect Ratio: The ratio of the length of a fiber to it's diameter (e.g. 3:1, 5:1 aspect ratios).

Cleavage Fragments: Mineral particles formed by comminution of minerals, especially those characterized by parallel sides and a moderate aspect ratio (usually less than 20:1).

Detection Limit: The number of fibers necessary to be 95% certain that the result is greater than zero.

Differential Counting: The term applied to the practice of excluding certain kinds of fibers from the fiber count because they do not appear to be asbestos.

Fiber: A particle that is 5 um or longer, with a length-to-width ratio of 3 to 1 or longer.

Field: The area within the graticule circle that is superimposed on the microscope image.

Set: The samples which are taken, submitted to the laboratory, analyzed, and for which, interim or final result reports are generated.

Tremolite, Anthophyllite, and Actinolite: The non-asbestos form of these minerals which meet the definition of a fiber. It includes any of these minerals that have been chemically treated and/or altered.

Walton-Beckett Graticule: An eyepiece graticule specifically designed for asbestos fiber counting. It consists of a circle with a projected diameter of 100 plus or minus 2 um (area of about 0.00785 mm²) with a crosshair having tic-marks at 3-um intervals in one direction and 5-um in the orthogonal direction. There are marks around the periphery of the circle to demonstrate the proper sizes and shapes of fibers. This design is reproduced in Figure 1. The disk is placed in one of the microscope eyepieces so that the design is superimposed on the field of view.

1.1. History

Early surveys to determine asbestos exposures were conducted using impinger counts of total dust with the counts expressed as million particles per cubic foot. The British Asbestos Research Council recommended filter membrane counting in 1969. In July 1969, the Bureau of Occupational Safety and Health published a filter membrane method for counting asbestos fibers in the United States. This method was refined by NIOSH and published as P & CAM 239. On May 29, 1971, OSHA specified filter membrane sampling with phase contrast counting for evaluation of asbestos exposures at work sites in the United States. The use of this technique was again required by OSHA in 1986. Phase contrast microscopy has continued to be the method of choice for the measurement of occupational exposure to asbestos.

1.2. Principle

Air is drawn through a MCE filter to capture airborne asbestos fibers. A wedge shaped portion of the filter is removed, placed on a glass microscope slide and made transparent. A measured area (field) is viewed by PCM. All the fibers meeting defined criteria for asbestos are counted and considered a measure of the airborne asbestos concentration.

1.3. Advantages and Disadvantages

There are four main advantages of PCM over other methods:

- (1) The technique is specific for fibers. Phase contrast is a fiber counting technique which excludes non-fibrous particles from the analysis.
- (2) The technique is inexpensive and does not require specialized knowledge to carry out the analysis for total fiber counts.
- (3) The analysis is quick and can be performed on-site for rapid determination of air concentrations of asbestos fibers.
- (4) The technique has continuity with historical epidemiological studies so that estimates of expected disease can be inferred from long-term determinations of asbestos exposures.

The main disadvantage of PCM is that it does not positively identify asbestos fibers. Other fibers which are not asbestos may be included in the count unless differential counting is performed. This requires a great deal of experience to adequately differentiate asbestos from non-asbestos fibers. Positive identification of asbestos must be performed by polarized light or electron microscopy techniques. A further disadvantage of PCM is that the smallest visible fibers are about 0.2 μm in diameter while the finest asbestos fibers may be as small as 0.02 μm in diameter. For some exposures, substantially more fibers may be present than are actually counted.

1.4. Workplace Exposure

Asbestos is used by the construction industry in such products as shingles, floor tiles, asbestos cement, roofing felts, insulation and acoustical products. Non-construction uses include brakes, clutch facings, paper, paints, plastics, and fabrics. One of the most significant exposures in the workplace is the removal and encapsulation of asbestos in schools, public

buildings, and homes. Many workers have the potential to be exposed to asbestos during these operations.

About 95% of the asbestos in commercial use in the United States is chrysotile. Crocidolite and amosite make up most of the remainder. Anthophyllite and tremolite or actinolite are likely to be encountered as contaminants in various industrial products.

1.5. Physical Properties

Asbestos fiber possesses a high tensile strength along its axis, is chemically inert, non-combustible, and heat resistant. It has a high electrical resistance and good sound absorbing properties. It can be weaved into cables, fabrics or other textiles, and also matted into asbestos papers, felts, or mats.

2. Range and Detection Limit

2.1. The ideal counting range on the filter is 100 to 1,300 fibers/mm(2). With a Walton-Beckett graticule this range is equivalent to 0.8 to 10 fibers/field. Using NIOSH counting statistics, a count of 0.8 fibers/field would give an approximate coefficient of variation (CV) of 0.13.

2.2. The detection limit for this method is 4.0 fibers per 100 fields or 5.5 fibers/mm(2). This was determined using an equation to estimate the maximum CV possible at a specific concentration (95% confidence) and a Lower Control Limit of zero. The CV value was then used to determine a corresponding concentration from historical CV vs fiber relationships. As an example:

$$\text{Lower Control Limit (95\% Confidence)} = AC - 1.645(CV)(AC)$$

Where:

AC = Estimate of the airborne fiber concentration (fibers/cc) Setting the
Lower Control Limit = 0 and solving for CV:
0 = AC - 1.645(CV)(AC)
CV = 0.61

This value was compared with CV vs. count curves. The count at which CV = 0.61 for Leidel-Busch counting statistics or for an OSHA Salt Lake Technical Center (OSHA-SLTC) CV curve (see Appendix A for further information) was 4.4 fibers or 3.9 fibers per 100 fields, respectively. Although a lower detection limit of 4 fibers per 100 fields is supported by the OSHA-SLTC data, both data sets support the 4.5 fibers per 100 fields value.

3. Method Performance -- Precision and Accuracy

Precision is dependent upon the total number of fibers counted and the uniformity of the fiber distribution on the filter. A general rule is to count at least 20 and not more than 100 fields. The count is discontinued when 100 fibers are counted, provided that 20 fields have already been counted. Counting more than 100 fibers results in only a small gain in precision. As the total count drops below 10 fibers, an accelerated loss of precision is noted.

At this time, there is no known method to determine the absolute accuracy of the asbestos analysis. Results of samples prepared through the Proficiency Analytical Testing (PAT) Program and analyzed by the OSHA-SLTC showed no significant bias when compared to PAT reference values. The PAT samples were analyzed from 1987 to 1989 (N = 36) and the concentration range was from 120 to 1,300 fibers/mm(2).

4. Interferences

Fibrous substances, if present, may interfere with asbestos analysis.

Some common fibers are:

- Fiberglass
- Anhydrite
- Plant Fibers
- Perlite Veins
- Gypsum
- Some Synthetic Fibers
- Membrane Structures
- Sponge Spicules
- Diatoms
- Microorganisms
- Wollastonite

The use of electron microscopy or optical tests such as polarized light, and dispersion staining may be used to differentiate these materials from asbestos when necessary.

5. Sampling

5.1. Equipment

5.1.1. Sample assembly (The assembly is shown in Figure 3). Conductive filter holder consisting of a 25-mm diameter, 3-piece cassette having a 50-mm long electrically conductive extension cowl. Backup pad, 25-mm, cellulose. Membrane filter, mixed-cellulose ester (MCE), 25-mm, plain, white, 0.4 to 1.2-um pore size.

Notes:

(a) DO NOT RE-USE CASSETTES.

(b) Fully conductive cassettes are required to reduce fiber loss to the sides of the cassette due to electrostatic attraction.

(c) Purchase filters which have been selected by the manufacturer for asbestos counting or analyze representative filters for fiber background before use. Discard the filter lot if more than 4 fibers/ 100 fields are found.

(d) To decrease the possibility of contamination, the sampling system (filter-backup pad-cassette) for asbestos is usually preassembled by the manufacturer.

(e) Other cassettes, such as the Bell-mouth, may be used within the limits of their validation.

5.1.2. Gel bands for sealing cassettes.

5.1.3. Sampling pump.

Each pump must be a battery operated, self-contained unit small enough to be placed on the monitored employee and not interfere with the work being performed. The pump must be capable of sampling at the collection rate for the required sampling time.

5.1.4. Flexible tubing, 6-mm bore.

5.1.5. Pump calibration.

Stopwatch and bubble tube/burette or electronic meter.

5.2. Sampling Procedure

5.2.1. Seal the point where the base and cowl of each cassette meet with a gel band or tape.

5.2.2. Charge the pumps completely before beginning.

5.2.3. Connect each pump to a calibration cassette with an appropriate length of 6-mm bore plastic tubing. Do not use luer connectors -- the type of cassette specified above has built-in adapters.

5.2.4. Select an appropriate flow rate for the situation being monitored. The sampling flow rate must be between 0.5 and 5.0 L/min for personal sampling and is commonly set between 1 and 2 L/min. Always choose a flow rate that will not produce overloaded filters.

5.2.5. Calibrate each sampling pump before and after sampling with a calibration cassette in-line (Note: This calibration cassette should be from the same lot of cassettes used for sampling). Use a primary standard (e.g. bubble burette) to calibrate each pump. If possible, calibrate at the sampling site.

Note: If sampling site calibration is not possible, environmental influences may affect the flow rate. The extent is dependent on the type of pump used. Consult with the pump manufacturer to determine dependence on environmental influences. If the pump is affected by temperature and pressure changes, correct the flow rate using the formula shown in the section "Sampling Pump Flow Rate Corrections" at the end of this appendix.

5.2.6. Connect each pump to the base of each sampling cassette with flexible tubing. Remove the end cap of each cassette and take each air sample open face. Assure that each sample cassette is held open side down in the employee's breathing zone during sampling. The distance from the nose/mouth of the employee to the cassette should be about 10 cm. Secure the cassette on the collar or lapel of the employee using spring clips or other similar devices.

5.2.7. A suggested minimum air volume when sampling to determine TWA compliance is 25

L. For Excursion Limit (30 min sampling time) evaluations, a minimum air volume of 48 L is recommended.

5.2.8. The most significant problem when sampling for asbestos is overloading the filter with non-asbestos dust. Suggested maximum air sample volumes for specific environments are:

Environment	Air Vol. (L)
Asbestos removal operations (visible dust).....	100.
Asbestos removal operations (little dust).....	240.
Office environments.....	400 to 2,400.

CAUTION: Do not overload the filter with dust. High levels of non-fibrous dust particles may obscure fibers on the filter and lower the count or make counting impossible. If more than about 25 to 30% of the field area is obscured with dust, the result may be biased low. Smaller air volumes may be necessary when there is excessive non-asbestos dust in the air.

While sampling, observe the filter with a small flashlight. If there is a visible layer of dust on the filter, stop sampling, remove and seal the cassette, and replace with a new sampling assembly. The total dust loading should not exceed 1 mg.

5.2.9. Blank samples are used to determine if any contamination has occurred during sample handling. Prepare two blanks for the first 1 to 20 samples. For sets containing greater than 20 samples, prepare blanks as 10% of the samples. Handle blank samples in the same manner as air samples with one exception: Do not draw any air through the blank samples. Open the blank cassette in the place where the sample cassettes are mounted on the employee. Hold it open for about 30 seconds. Close and seal the cassette appropriately. Store blanks for shipment with the sample cassettes.

5.2.10. Immediately after sampling, close and seal each cassette with the base and plastic plugs. Do not touch or puncture the filter membrane as this will invalidate the analysis.

5.2.11. Attach and secure a sample seal around each sample cassette in such a way as to assure that the end cap and base plugs cannot be removed without destroying the seal. Tape the ends of the seal together since the seal is not long enough to be wrapped end-to-end. Also wrap tape around the cassette at each joint to keep the seal secure.

5.3. Sample Shipment

5.3.1. Send the samples to the laboratory with paperwork requesting asbestos analysis. List any known fibrous interferences present during sampling on the paperwork. Also, note the workplace operation(s) sampled.

5.3.2. Secure and handle the samples in such that they will not rattle during shipment nor be exposed to static electricity. Do not ship samples in expanded polystyrene peanuts, vermiculite, paper shreds, or excelsior. Tape sample cassettes to sheet bubbles and place in a

container that will cushion the samples in such a manner that they will not rattle.

5.3.3. To avoid the possibility of sample contamination, always ship bulk samples in separate mailing containers.

6. Analysis

6.1. Safety Precautions

6.1.1. Acetone is extremely flammable and precautions must be taken not to ignite it. Avoid using large containers or quantities of acetone. Transfer the solvent in a ventilated laboratory hood. Do not use acetone near any open flame. For generation of acetone vapor, use a spark free heat source.

6.1.2. Any asbestos spills should be cleaned up immediately to prevent dispersal of fibers. Prudence should be exercised to avoid contamination of laboratory facilities or exposure of personnel to asbestos. Asbestos spills should be cleaned up with wet methods and/ or a High Efficiency Particulate-Air (HEPA) filtered vacuum.

CAUTION: Do not use a vacuum without a HEPA filter -- It will disperse fine asbestos fibers in the air.

6.2. Equipment

6.2.1. Phase contrast microscope with binocular or trinocular head.

6.2.2. Widefield or Huygenian 10X eyepieces (NOTE: The eyepiece containing the graticule must be a focusing eyepiece. Use a 40X phase objective with a numerical aperture of 0.65 to 0.75).

6.2.3. Kohler illumination (if possible) with green or blue filter.

6.2.4. Walton-Beckett Graticule, type G-22 with 100 plus or minus 2 μ m projected diameter.

6.2.5. Mechanical stage. A rotating mechanical stage is convenient for use with polarized light.

6.2.6. Phase telescope.

6.2.7. Stage micrometer with 0.01-mm subdivisions.

6.2.8. Phase-shift test slide, mark II (Available from PTR optics Ltd., and also McCrone).

6.2.9. Precleaned glass slides, 25 mm X 75 mm. One end can be frosted for convenience in writing sample numbers, etc., or paste-on labels can be used.

6.2.10. Cover glass #1 1/2.

6.2.11. Scalpel (#10, curved blade).

6.2.12. Fine tipped forceps.

6.2.13. Aluminum block for clearing filter (see Appendix D and Figure 4).

6.2.14. Automatic adjustable pipette, 100- to 500-uL.

6.2.15. Micropipette, 5 uL.

6.3. Reagents

6.3.1. Acetone (HPLC grade).

6.3.2. Triacetin (glycerol triacetate).

6.3.3. Lacquer or nail polish.

6.4. Standard Preparation

A way to prepare standard asbestos samples of known concentration has not been developed. It is possible to prepare replicate samples of nearly equal concentration. This has been performed through the PAT program. These asbestos samples are distributed by the AIHA to participating laboratories.

Since only about one-fourth of a 25-mm sample membrane is required for an asbestos count, any PAT sample can serve as a "standard" for replicate counting.

6.5. Sample Mounting

Note: See Safety Precautions in Section 6.1. before proceeding. The objective is to produce samples with a smooth (non-grainy) background in a medium with a refractive index of approximately 1.46. The technique below collapses the filter for easier focusing and produces permanent mounts which are useful for quality control and interlaboratory comparison.

An aluminum block or similar device is required for sample preparation.

6.5.1. Heat the aluminum block to about 70 deg.C. The hot block should not be used on any surface that can be damaged by either the heat or from exposure to acetone.

6.5.2. Ensure that the glass slides and cover glasses are free of dust and fibers.

6.5.3. Remove the top plug to prevent a vacuum when the cassette is opened. Clean the outside of the cassette if necessary. Cut the seal and/or tape on the cassette with a razor blade. Very carefully separate the base from the extension cowl, leaving the filter and backup pad in the base.

6.5.4. With a rocking motion cut a triangular wedge from the filter using the scalpel. This wedge should be one-sixth to one-fourth of the filter. Grasp the filter wedge with the forceps on the perimeter of the filter which was clamped between the cassette pieces. DO NOT

TOUCH the filter with your finger. Place the filter on the glass slide sample side up. Static electricity will usually keep the filter on the slide until it is cleared.

6.5.5. Place the tip of the micropipette containing about 200 μL acetone into the aluminum block. Insert the glass slide into the receiving slot in the aluminum block. Inject the acetone into the block with slow, steady pressure on the plunger while holding the pipette firmly in place. Wait 3 to 5 seconds for the filter to clear, then remove the pipette and slide from the aluminum block.

6.5.6. Immediately (less than 30 seconds) place 2.5 to 3.5 μL of triacetin on the filter (NOTE: Waiting longer than 30 seconds will result in increased index of refraction and decreased contrast between the fibers and the preparation. This may also lead to separation of the cover slip from the slide).

6.5.7. Lower a cover slip gently onto the filter at a slight angle to reduce the possibility of forming air bubbles. If more than 30 seconds have elapsed between acetone exposure and triacetin application, glue the edges of the cover slip to the slide with lacquer or nail polish.

6.5.8. If clearing is slow, warm the slide for 15 min on a hot plate having a surface temperature of about 50 deg.C to hasten clearing. The top of the hot block can be used if the slide is not heated too long.

6.5.9. Counting may proceed immediately after clearing and mounting are completed.

6.6. Sample Analysis

Completely align the microscope according to the manufacturer's instructions. Then, align the microscope using the following general alignment routine at the beginning of every counting session and more often if necessary.

6.6.1. Alignment

- (1) Clean all optical surfaces. Even a small amount of dirt can significantly degrade the image.
- (2) Rough focus the objective on a sample.
- (3) Close down the field iris so that it is visible in the field of view. Focus the image of the iris with the condenser focus. Center the image of the iris in the field of view.
- (4) Install the phase telescope and focus on the phase rings. Critically center the rings. Misalignment of the rings results in astigmatism which will degrade the image.
- (5) Place the phase-shift test slide on the microscope stage and focus on the lines. The analyst must see line set 3 and should see at least parts of 4 and 5 but, not see line set 6 or 6. A microscope/microscopist combination which does not pass this test may not be used.

6.6.2. Counting Fibers

- (1) Place the prepared sample slide on the mechanical stage of the microscope. Position the

center of the wedge under the objective lens and focus upon the sample.

(2) Start counting from one end of the wedge and progress along a radial line to the other end (count in either direction from perimeter to wedge tip). Select fields randomly, without looking into the eyepieces, by slightly advancing the slide in one direction with the mechanical stage control.

(3) Continually scan over a range of focal planes (generally the upper 10 to 15 μm of the filter surface) with the fine focus control during each field count. Spend at least 5 to 15 seconds per field.

(4) Most samples will contain asbestos fibers with fiber diameters less than 1 μm . Look carefully for faint fiber images. The small diameter fibers will be very hard to see. However, they are an important contribution to the total count.

(5) Count only fibers equal to or longer than 5 μm . Measure the length of curved fibers along the curve.

(6) Count fibers which have a length to width ratio of 3:1 or greater.

(7) Count all the fibers in at least 20 fields. Continue counting until either 100 fibers are counted or 100 fields have been viewed; whichever occurs first. Count all the fibers in the final field.

(8) Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle shall receive a count of 1/2. Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area. If a fiber touches the circle, it is considered to cross the line.

(9) Count bundles of fibers as one fiber unless individual fibers can be clearly identified and each individual fiber is clearly not connected to another counted fiber. See Figure 1 for counting conventions.

(10) Record the number of fibers in each field in a consistent way such that filter non-uniformity can be assessed.

(11) Regularly check phase ring alignment.

(12) When an agglomerate (mass of material) covers more than 25% of the field of view, reject the field and select another. Do not include it in the number of fields counted.

(13) Perform a "blind recount" of 1 in every 10 filter wedges (slides). Re-label the slides using a person other than the original counter.

6.7. Fiber Identification

As previously mentioned in Section 1.3., PCM does not provide positive confirmation of asbestos fibers. Alternate differential counting techniques should be used if discrimination is

desirable. Differential counting may include primary discrimination based on morphology, polarized light analysis of fibers, or modification of PCM data by Scanning Electron or Transmission Electron Microscopy.

A great deal of experience is required to routinely and correctly perform differential counting. It is discouraged unless it is legally necessary. Then, only if a fiber is obviously not asbestos should it be excluded from the count. Further discussion of this technique can be found in reference 8.10.

If there is a question whether a fiber is asbestos or not, follow the rule:

"WHEN IN DOUBT, COUNT."

6.8. Analytical Recommendations -- Quality Control System

6.8.1. All individuals performing asbestos analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos or an equivalent course.

6.8.2. Each laboratory engaged in asbestos counting shall set up a slide trading arrangement with at least two other laboratories in order to compare performance and eliminate inbreeding of error. The slide exchange occurs at least semiannually. The round robin results shall be posted where all analysts can view individual analyst's results.

6.8.3. Each laboratory engaged in asbestos counting shall participate in the Proficiency Analytical Testing Program, the Asbestos Analyst Registry or equivalent.

6.8.4. Each analyst shall select and count prepared slides from a "slide bank". These are quality assurance counts. The slide bank shall be prepared using uniformly distributed samples taken from the workload. Fiber densities should cover the entire range routinely analyzed by the laboratory. These slides are counted blind by all counters to establish an original standard deviation. This historical distribution is compared with the quality assurance counts. A counter must have 95% of all quality control samples counted within three standard deviations of the historical mean. This count is then integrated into a new historical mean and standard deviation for the slide.

The analyses done by the counters to establish the slide bank may be used for an interim quality control program if the data are treated in a proper statistical fashion.

7. Calculations

7.1. Calculate the estimated airborne asbestos fiber concentration on the filter sample using the following formula:

(For Equation A, [Click Here](#))

where:

AC = Airborne fiber concentration
FB = Total number of fibers greater than 5 um counted
FL = Total number of fields counted on the filter
BFB = Total number of fibers greater than 5 um counted in the blank

BFL = Total number of fields counted on the blank
 ECA = Effective collecting area of filter (385 mm²) nominal for a 25-mm filter.)
 FR = Pump flow rate (L/min)
 MFA = Microscope count field area (mm²). This is 0.00785 mm² for a Walton-Beckett Graticule.
 T = Sample collection time (min)
 1,000 = Conversion of L to cc

Note: The collection area of a filter is seldom equal to 385 mm². It is appropriate for laboratories to routinely monitor the exact diameter using an inside micrometer. The collection area is calculated according to the formula:

$$\text{Area} = \pi(d/2)^2$$

7.2. Short-Cut Calculation

Since a given analyst always has the same interpupillary distance, the number of fields per filter for a particular analyst will remain constant for a given size filter. The field size for that analyst is constant (i.e. the analyst is using an assigned microscope and is not changing the reticle).

For example, if the exposed area of the filter is always 385 mm² and the size of the field is always 0.00785 mm² the number of fields per filter will always be 49,000. In addition it is necessary to convert liters of air to cc. These three constants can then be combined such that $ECA/(1,000 \times MFA) = 49$. The previous equation simplifies to:

(For Equation B, [Click Here](#))

7.3. Recount Calculations

As mentioned in step 13 of Section 6.6.2., a "blind recount" of 10% of the slides is performed. In all cases, differences will be observed between the first and second counts of the same filter wedge. Most of these differences will be due to chance alone, that is, due to the random variability (precision) of the count method. Statistical recount criteria enables one to decide whether observed differences can be explained due to chance alone or are probably due to systematic differences between analysts, microscopes, or other biasing factors.

The following recount criterion is for a pair of counts that estimate AC in fibers/cc. The criterion is given at the type-I error level. That is, there is 5% maximum risk that we will reject a pair of counts for the reason that one might be biased, when the large observed difference is really due to chance.

Reject a pair of counts if:

(For Equation C, [Click Here](#))

Where:

AC(1) = lower estimated airborne fiber concentration
 AC(2) = higher estimated airborne fiber concentration
 AC(avg) = average of the two concentration estimates

CV(FB) = CV for the average of the two concentration estimates

If a pair of counts are rejected by this criterion then, recount the rest of the filters in the submitted set. Apply the test and reject any other pairs failing the test. Rejection shall include a memo to the industrial hygienist stating that the sample failed a statistical test for homogeneity and the true air concentration may be significantly different than the reported value.

7.4. Reporting Results

Report results to the industrial hygienist as fibers/cc. Use two significant figures. If multiple analyses are performed on a sample, an average of the results is to be reported unless any of the results can be rejected for cause.

8. References

8.1. Dreesen, W.C., et al., U.S. Public Health Service: A Study of Asbestosis in the Asbestos Textile Industry (Public Health Bulletin No. 241), U.S. Treasury Dept., Washington, DC, 1938.

8.2. Asbestos Research Council: The Measurement of Airborne Asbestos Dust by the Membrane Filter Method (Technical Note), Asbestos Research Council, Rockdale, Lancashire, Great Britain, 1969.

8.3. Bayer, S.G., Zumwalde, R.D., Brown, T.A., Equipment and Procedure for Mounting Millipore Filters and Counting Asbestos Fibers by Phase Contrast Microscopy, Bureau of Occupational Health, U.S. Dept. of Health, Education and Welfare, Cincinnati, OH, 1969.

8.4. NIOSH Manual of Analytical Methods, 2nd ed., Vol. 1 (DHEW/ NIOSH Pub. No. 77-157-A). National Institute for Occupational Safety and Health, Cincinnati, OH, 1977. pp. 239-1 -- 239-21.

8.5. Asbestos, Code of Federal Regulations 29 CFR 1910.1001. 1971.

8.6. Occupational Exposure to Asbestos, Tremolite, Anthophyllite, and Actinolite. Final Rule, Federal Register 51:119 (20 June 1986). pp. 22612-22790.

8.7. Asbestos, Tremolite, Anthophyllite, and Actinolite, Code of Federal Regulations 1910.1001. 1988. pp. 711-752.

8.8. Criteria for a Recommended Standard -- Occupational Exposure to Asbestos (DHEW/NIOSH Pub. No. HSM 72-10267), National Institute for Occupational Safety and Health, NIOSH, Cincinnati, OH, 1972. pp. III-1 -- III-24.

8.9. Leidel, N.A., Bayer, S.G., Zumwalde, R.D., Busch, K.A., USPHS/NIOSH Membrane Filter Method for Evaluating Airborne Asbestos Fibers (DHEW/NIOSH Pub. No. 79-127). National Institute for Occupational Safety and Health, Cincinnati, OH, 1979.

8.10. Dixon, W.C., Applications of Optical Microscopy in Analysis of Asbestos and Quartz, Analytical Techniques in Occupational Health Chemistry, edited by D.D. Dollberg and A.W. Verstuyft. Wash. D.C.: American Chemical Society, (ACS Symposium Series 120) 1980. pp. 13-41.

Quality Control

The OSHA asbestos regulations require each laboratory to establish a quality control program. The following is presented as an example of how the OSHA-SLTC constructed its internal CV curve as part of meeting this requirement. Data is from 395 samples collected during OSHA compliance inspections and analyzed from October 1980 through April 1986.

Each sample was counted by 2 to 5 different counters independently of one another. The standard deviation and the CV statistic was calculated for each sample. This data was then plotted on a graph of CV vs. fibers/mm(2). A least squares regression was performed using the following equation:

$$CV = \text{antilog}(10) [A(\log(10)(x))^2 + B(\log(10)(x)) + C]$$

where:

x = the number of fibers/mm(2)

Application of least squares gave:

A = 0.182205

B = 0.973343

C = 0.327499

Using these values, the equation becomes:

$$CV = \text{antilog}(10) [0.182205(\log(10)(x))^2 - 0.973343(\log(10)(x)) + 0.327499]$$

Sampling Pump Flow Rate Corrections

This correction is used if a difference greater than 5% in ambient temperature and/or pressure is noted between calibration and sampling sites and the pump does not compensate for the differences.

(For Equation D, [Click Here](#))

Where:

Q(act) = actual flow rate

Q(cal) = calibrated flow rate (if a rotameter was used, the rotameter value)

P(cal) = uncorrected air pressure at calibration

P(act) = uncorrected air pressure at sampling site

T(act) = temperature at sampling site (K)

T(cal) = temperature at calibration (K)

Walton-Beckett Graticule

When ordering the Graticule for asbestos counting, specify the exact disc diameter needed to

fit the ocular of the microscope and the diameter (mm) of the circular counting area. Instructions for measuring the dimensions necessary are listed:

- (1) Insert any available graticule into the focusing eyepiece and focus so that the graticule lines are sharp and clear.
- (2) Align the microscope.
- (3) Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.
- (4) Measure the magnified grid length, PL (um), using the stage micrometer.
- (5) Remove the graticule from the microscope and measure its actual grid length, AL (mm). This can be accomplished by using a mechanical stage fitted with verniers, or a jeweler's loupe with a direct reading scale.
- (6) Let $D = 100 \text{ um}$. Calculate the circle diameter, $d(c)(\text{mm})$, for the Walton-Beckett graticule and specify the diameter when making a purchase:

$$d(c) = \frac{AL \times D}{PL}$$

Example:

If $PL = 108 \text{ um}$, $AL = 2.93 \text{ mm}$ and $D = 100 \text{ um}$,

then,

$$d(c) = \frac{2.93 \times 100}{108} = 2.71 \text{ mm}$$

- (7) Each eyepiece-objective-reticle combination on the microscope must be calibrated. Should any of the three be changed (by zoom adjustment, disassembly, replacement, etc.), the combination must be recalibrated. Calibration may change if interpupillary distance is changed.

Measure the field diameter, D (acceptable range: $100 \text{ plus or minus } 2 \text{ um}$) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine the field area (mm^2).

$$\text{Field Area} = \pi (D/2)^2$$

If $D = 100 \text{ um} = 0.1 \text{ mm}$, then

$$\text{Field Area} = \pi (0.1 \text{ mm}/2)^2 = 0.00785 \text{ mm}^2$$

The Graticule is available from: Graticules Ltd., Morley Road, Tonbridge TN9 1RN, Kent, England (Telephone 011-44-732-359061). Also available from PTR Optics Ltd., 145 Newton Street, Waltham, MA 02154 [telephone (617) 891-6000] or McCrone Accessories and Components, 2506 S. Michigan Ave., Chicago, IL 60616 [phone (312)-842-7100]. The

graticule is custom made for each microscope.

(For Figure 1 of Walton-Beckett Graticule, [Click Here](#))

Counts for the Fibers in the Figure

Structure No.	Count	Explanation
1 to 6.....	1	Single fibers all contained within the Circle.
7.....	1/2	Fiber crosses circle once.
8.....	0	Fiber too short.
9.....	2	Two crossing fibers.
10.....	0	Fiber outside graticule.
11.....	0	Fiber crosses graticule twice.
12.....	1/2	Although split, fiber only crosses once.

[60 FR 33972, June 29, 1995]

[Next Standard \(1926.1101 App C\)](#)

[Regulations \(Standards - 29 CFR\) - Table of Contents](#)

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Occupational Safety & Health Administration
200 Constitution Avenue, NW
Washington, DC 20210

Appendix L

Federal and State Applicable or Relevant and Appropriate Requirements (ARARs)

**ARAR'S FOR THE HYDRATED BIOTITE SOIL REMOVAL AND DISPOSAL
BURLINGTON NORTHERN SANTA FE RAILWAY COMPANY
LIBBY, MONTANA**

Citation	Requirement or Activity	Compliance Strategy
29 CFR 1910.134	Use of respiratory protection.	<ul style="list-style-type: none"> Each employer will be responsible for compliance with this standard. Full-face PAPR's will be used initially with the possibility of downgrading to negative pressure full-face respirators.
29 CFR 1910.134, 29 CFR 1926.95, 29 CFR 1926.96, 29 CFR 1926.100, 29 CFR 1926.101, 29 CFR 1926.102, 29 CFR 1926.103	Site work requires the use of personal protective equipment.	<ul style="list-style-type: none"> Personal protective equipment is to be worn on-site at all times. The minimum personal protective equipment will include a hard hat, safety glasses, safety boots, and hearing protection during vacuum truck operation. This equipment will comply with applicable ANSI standards. Additional personal protective equipment required in the Contamination Reduction Zone and Exclusion Zone and this will include respiratory protection, disposal suits, and protective gloves.
29 CFR 1910.151(b)	In the absence of an infirmary, clinic, or hospital in near proximity to the workplace which is used for the treatment of all injured employees, a person or persons shall be adequately trained to render first aid. Adequate first aid supplies shall be readily available.	St John's Lutheran Hospital at 350 Louisiana Avenue, Libby, is less than one mile from the work areas. Therefore, this regulation is not applicable.

**ARAR'S FOR THE HYDRATED BIOTITE SOIL REMOVAL AND DISPOSAL
BURLINGTON NORTHERN SANTA FE RAILWAY COMPANY
LIBBY, MONTANA**

Citation	Requirement or Activity	Compliance Strategy
29 CFR 1926.1101 (29 CFR 1910.1001)	Worker protection measures to include engineering controls, worker training, labeling, respiratory protection, bagging of waste, 0.1 f/cc eight-hour time-weighted average and 1 f/cc 30-minute excursion permissible exposure limit.	<ul style="list-style-type: none"> • Requirements of these standards have been addressed in the project specification. Some of the worker protection measures are listed below. • Engineering controls will include keeping the soil wet and decontamination facilities for personnel and equipment. Additionally, the HEPA-filtered vacuum truck is another engineering control in that it captures dust generated in the vacuuming process. • Workers are to be trained in accordance with federal asbestos abatement requirements and licensed by the State of Montana for asbestos abatement work before starting work at the site. A requirement of asbestos licensure is that they have proper training for their job designation. • Plastic-wrapped soil in dumpsters will be labeled before it is transported off the site in bulk. Additionally, bags of waste will have the appropriate asbestos warning label. • Signs and/or warning tape and traffic cones will be used at the site perimeter to keep unauthorized personnel out of the site and Exclusion Zone. • Waste generated from personal protective equipment and during decontamination is to be disposed of in asbestos warning-labeled 6-mil bags. The bags are to be leak-tight polyethylene bags labeled in accordance with 29 CFR 1910.1200(f) of OSHA's Hazard Communication standard. • Respiratory protection and protective clothing will be worn by personnel entering the Exclusion Zone. • Worker breathing zone samples will be collected from workers in the Exclusion Zone to document exposure. Additionally, area samples will be collected at the Exclusion Zone perimeter. Decisions to upgrade respiratory protection will be based on the airborne concentrations detected and the maximum use concentrations of the respirators being used.
40 CFR 61.154	Disposal of asbestos-containing waste	Material generated with the project is to be disposed of in a landfill operated by Lincoln County, Montana.

**ARAR'S FOR THE HYDRATED BIOTITE SOIL REMOVAL AND DISPOSAL
BURLINGTON NORTHERN SANTA FE RAILWAY COMPANY
LIBBY, MONTANA**

Citation	Requirement or Activity	Compliance Strategy
40 CFR Part 763.90	The removal project is completed after visible hydrated biotite has been removed and the soil samples do not detect Libby amphibole.	<ul style="list-style-type: none"> Each work area will be inspected and a "Certification of Visual Inspection" will be completed to document that each area has been visually inspected. EMR will collect soil samples to document Libby amphibole content of the soil following cleaning.
42 CFR Part 84	Respirator filter selection	Although other filters may provide adequate protection, P100 have been specified in the EMR Work Plan.
49 CFR parts 171 and 172	Regulates the transportation of asbestos-containing waste material. Requires waste containment and shipping papers.	A shipment record is to accompany the shipment to the landfill. A vessel lined with polyethylene sheeting will be used for waste transportation.
American National Standard for High-Visibility Safety Apparel ANSI/ISEA 107-1999	Exposure to vehicular equipment at the site.	Class 2 garments should be worn since they are intended for use in activities where greater visibility is necessary during inclement weather conditions or in work environments with risks that exceed those for Class 1.
ARAR's for preventing damage to unique or sensitive areas, such as floodplains, historic places, wetlands, and fragile ecosystems, and for restricting other activities that are potentially harmful because of where they take place.	Site work	The project site is a BNSF Railroad Company right-of-way. Therefore, issues with respect to floodplains, historic places, wetlands, fragile ecosystems, or activities that may be potentially harmful are not applicable.
Backup Alarm - citable under Section 5(a) (1) of the Occupational Safety and Health Act.	Under Section 5(a)(1) of the Occupational Safety and Health Act (the General Duty Clause), employers must keep their workplaces free from recognized hazards	Backup alarms on heavy equipment are required.

**ARAR'S FOR THE HYDRATED BIOTITE SOIL REMOVAL AND DISPOSAL
BURLINGTON NORTHERN SANTA FE RAILWAY COMPANY
LIBBY, MONTANA**

Citation	Requirement or Activity	Compliance Strategy
Emission Control requirements of 40 CFR 61.145 and Waste handling provisions of 40 CFR 61.150	Prevent visible emissions during vacuuming, soil transfer, loading the soil into vessels for transfer to the landfill.	<ul style="list-style-type: none"> • The HEPA-filtered vacuum trucks will capture airborne particulate as it is generated in the vacuuming process and thus prevent visible emissions. Additionally, soils are to be wetted prior to handling and they are to remain wet throughout handling so that no visible emissions are released from the site. • Soils for disposal will be transferred to a container lined with 6-mil polyethylene sheeting and waste will be transported to the landfill in bulk. • Each truckload of soil will be manifested using a special waste manifest. Photocopies of the manifests will be retained by EMR and the originals will be supplied to BNSF for their records. • Air sampling will be conducted during vacuuming, loading, and decontamination procedures in order to sample for potential airborne fibers.
	Asbestos-containing waste transportation and disposal at the approved landfill.	<ul style="list-style-type: none"> • EMR on behalf of BNSF and the transporter will ensure that a waste shipment record has been appropriately completed and signed by the generator, and accompanies the waste to the disposal site. • A copy of the waste shipment record is to be provided to the landfill operator or owner. • A copy signed by the landfill owner or operator is to be returned to BNSF within 30 days.

**ARAR'S FOR THE HYDRATED BIOTITE SOIL REMOVAL AND DISPOSAL
BURLINGTON NORTHERN SANTA FE RAILWAY COMPANY
LIBBY, MONTANA**

Citation	Requirement or Activity	Compliance Strategy										
29 Code of Federal Regulations 1910.145(d)(4)	Caution signs warning of asbestos-containing material and/or asbestos-related activity.	<p>Vessels used to transport asbestos-containing waste material are to be posted during the loading and unloading of waste so that the signs are visible. The posting must:</p> <p>(1) Be displayed in such a manner and location that a person can easily read the legend.</p> <p>(2) Conform to the requirements for twenty inch by fourteen-inch [50.8-centimeter by 35.56-centimeter] upright format signs specified in title 29 Code of Federal Regulations 1910.145(d)(4) and this paragraph; and</p> <p>(3) Display the following legend in the lower panel with letter sizes and styles of a visibility at least equal to those specified below.</p> <table><thead><tr><th>Legend</th><th>Notation</th></tr></thead><tbody><tr><td>DANGER</td><td>2.5 cm [1 in.] Sans Serif, Gothic, or Block.</td></tr><tr><td>ASBESTOS DUST HAZARD</td><td>2.5 cm [1 in.] Sans Serif, Gothic, or Block.</td></tr><tr><td>CANCER AND LUNG DISEASE HAZARD</td><td>1.9 cm [3/4 in.] Sans Serif, Gothic, or Block.</td></tr><tr><td>Authorized Personnel Only</td><td>14 Point Gothic</td></tr></tbody></table>	Legend	Notation	DANGER	2.5 cm [1 in.] Sans Serif, Gothic, or Block.	ASBESTOS DUST HAZARD	2.5 cm [1 in.] Sans Serif, Gothic, or Block.	CANCER AND LUNG DISEASE HAZARD	1.9 cm [3/4 in.] Sans Serif, Gothic, or Block.	Authorized Personnel Only	14 Point Gothic
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Authorized Personnel Only	14 Point Gothic											
Montana Title 75. Environmental Protection Chapter 2. Air Quality, Part 5. Asbestos Control	Montana Department of Environmental Quality (DEQ) asbestos-related regulations.	<p>Most of the Montana DEQ regulations are not applicable because the project does not involve asbestos-containing materials in an indoor environment and material containing one percent or greater asbestos has not been detected at the site. However, there will be compliance with the following that may be applicable and/or relevant:</p> <ul style="list-style-type: none">• Site workers will be required to be accredited by Montana DEQ.• A courtesy notification will be sent to Montana DEQ, but a permit is not required since material containing at least one percent asbestos has not been detected at the site.										

Appendix M

**Asbestos Worker Protection;
Proposed Rule: 40 CFR Part 763**



Federal Register

Thursday,
April 27, 2000

Part VI

Environmental Protection Agency

40 CFR Part 763

Asbestos Worker Protection; Proposed
Rule

ENVIRONMENTAL PROTECTION AGENCY**40 CFR Part 763**

[OPPTS-62125A; FRL-6493-5]

RIN 2070-AC66

Asbestos Worker Protection**AGENCY:** Environmental Protection Agency (EPA).**ACTION:** Proposed rule.

SUMMARY: EPA proposes to modify a previously published proposed rule to amend the Asbestos Worker Protection Rule (WPR). This modified proposal would protect State and local government employees from the health risks of exposure to asbestos to the same extent as private sector workers by adopting for such employees the Asbestos Standards of the Occupational Safety and Health Administration (OSHA). The modified proposal would expand the WPR's coverage to State and local government employees who are performing construction work, custodial work, and automotive brake and clutch repair work (the WPR now applies solely to asbestos abatement projects, a subset of construction work). The proposed rule would cross-reference the

OSHA Asbestos Standards for Construction and for General Industry, so that amendments to these OSHA standards are directly and equally effective for employees covered by the WPR. It would also amend the Asbestos-in-Schools Rule to provide coverage under the WPR for employees of public local education agencies who perform operations, maintenance and repair activities. EPA is proposing this rule under section 6 of the Toxic Substances Control Act (TSCA).

DATES: Comments, identified by docket control number OPPTS-62125A, must be received on or before June 26, 2000. Requests that EPA hold an informal public hearing must be received on or before June 26, 2000. If a hearing is requested, EPA will publish a notice announcing the informal public hearing in the **Federal Register**.

ADDRESSES: Comments may be submitted by mail, electronically, or in person. Please follow the detailed instructions for each method as provided in Unit I. of the **SUPPLEMENTARY INFORMATION**. To ensure proper receipt by EPA, it is imperative that you identify docket control number OPPTS-62125A in the subject line on the first page of your response.

FOR FURTHER INFORMATION CONTACT: *For general information contact:* Barbara Cunningham, Director, Office of Program Management and Evaluation, Office of Pollution Prevention and Toxics (7401), Environmental Protection Agency, Ariel Rios Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460; telephone number: (202) 554-1404; e-mail address: TSCA-Hotline@epa.gov.

For technical information contact: Cindy Fraleigh, Attorney-Advisor, National Program Chemicals Division (7404), Office of Pollution Prevention and Toxics, Environmental Protection Agency, Ariel Rios Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460; telephone number: (202) 260-1537; fax number: (202) 260-1724; e-mail address: fraleigh.cindy@epa.gov.

SUPPLEMENTARY INFORMATION:**I. General Information***A. Does this Action Apply to Me?*

You may be potentially affected by this action if you are a State or local government entity whose employees work with or near asbestos-containing material. Potentially affected categories and entities may include, but are not limited to:

Categories	NAICS codes	Examples of potentially affected entities
Educational services	61	Public educational institutions, including school districts, not subject to an OSHA-approved State asbestos plan or a State asbestos worker protection plan that EPA has determined is exempt from the requirements of the WPR.
Public administration	92	State or local government employers not subject to an OSHA-approved State asbestos plan or a State asbestos worker protection plan that EPA has determined is exempt from the requirements of the WPR.

This listing is not intended to be exhaustive, but rather provides a guide for readers regarding entities likely to be affected by this action. Other types of entities not listed in this table could also be affected. The North American Industrial Classification System (NAICS) codes are provided to assist you and others in determining whether or not this action might apply to certain entities. If you have questions regarding the applicability of this action to a particular entity, consult the technical person listed under **FOR FURTHER INFORMATION CONTACT**.

B. How Can I Get Additional Information, Including Copies of this Document and Other Related Documents?

1. *Electronically.* You may obtain electronic copies of this document, and certain other related documents from the EPA Internet Home Page at <http://www.epa.gov/>. To access this document, on the Home Page select "Laws and Regulations" and then look up the entry for this document under the "Federal Register—Environmental Documents." You can also go directly to the **Federal Register** listings at <http://www.epa.gov/fedrgstr/>. To access information about asbestos, go directly to the Asbestos Home Page for the Office of Pollution Prevention and Toxics at <http://www.epa.gov/asbestos/>.

2. *In person.* The Agency has established an official record for this action under docket control number OPPTS-62125A. The official record consists of the documents specifically referenced in this action, any public comments received during an applicable comment period, and other information related to this action, including any information claimed as Confidential Business Information (CBI). This official record includes the documents that are physically located in the docket, as well as the documents that are referenced in those documents. The public version of the official record does not include any information claimed as CBI. The public version of the official record, which includes printed, paper versions of any electronic comments submitted during an applicable comment period, is

available for inspection in the TSCA Nonconfidential Information Center (NCIC), North East Mall Rm. B-607, Waterside Mall, 401 M St., SW., Washington, DC 20460, from noon to 4 p.m., Monday through Friday, excluding legal holidays. The NCIC telephone number is (202) 260-7099.

C. How and to Whom Do I Submit Comments?

You may submit comments through the mail, in person, or electronically. To ensure proper receipt by EPA, it is imperative that you identify docket control number OPPTS-62125A in the subject line on the first page of your response.

1. *By mail.* Submit comments to: Document Control Office (7407), Office of Pollution Prevention and Toxics (OPPT), Environmental Protection Agency, Ariel Rios Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460.

2. *In person or by courier.* Deliver comments to: OPPT Document Control Office (DCO) in East Tower Rm. G-099, Waterside Mall, 401 M St., SW., Washington, DC. The DCO is open from 8 a.m. to 4 p.m., Monday through Friday, excluding legal holidays. The telephone number for the DCO is (202) 260-7093.

3. *Electronically.* You may submit your comments electronically by e-mail to: "oppt-docket@epa.gov," or you can submit a computer disk as described above. Do not submit any information electronically that you consider to be CBI. Avoid the use of special characters and any form of encryption. Electronic submissions will be accepted in WordPerfect 6.1/8.0 or ASCII file format. All comments in electronic form must be identified by docket control number OPPTS-62125A. Electronic comments may also be filed online at many Federal Depository Libraries.

D. How Should I Handle CBI that I Want to Submit to the Agency?

Do not submit any information electronically that you consider to be CBI. You may claim information that you submit to EPA in response to this document as CBI by marking any part or all of that information as CBI. Information so marked will not be disclosed except in accordance with procedures set forth in 40 CFR part 2. In addition to one complete version of the comment that includes any information claimed as CBI, a copy of the comment that does not contain the information claimed as CBI must be submitted for inclusion in the public version of the official record. Information not marked confidential

will be included in the public version of the official record without prior notice. If you have any questions about CBI or the procedures for claiming CBI, please consult the technical person listed under **FOR FURTHER INFORMATION CONTACT**.

E. What Should I Consider as I Prepare My Comments for EPA?

You may find the following suggestions helpful for preparing your comments:

1. Explain your views as clearly as possible.
2. Describe any assumptions that you used.
3. Provide copies of any technical information and/or data you used that support your views.
4. If you estimate potential burden or costs, explain how you arrived at the estimate that you provide.
5. Provide specific examples to illustrate your concerns.
6. Offer alternative ways to improve the proposed rule.
7. Make sure to submit your comments by the deadline in this document.
8. To ensure proper receipt by EPA, be sure to identify the docket control number assigned to this action in the subject line on the first page of your response. You may also provide the name, date, and **Federal Register** citation.

F. How and to Whom Do I Submit an Informal Public Hearing Request?

You may request that EPA hold an informal public hearing, at which interested persons or organizations may present oral comments, by contacting the technical person listed under **FOR FURTHER INFORMATION CONTACT**. Requests for an informal hearing must be received on or before June 26, 2000. If EPA decides to hold an informal hearing, it will publish a notice in the **Federal Register** announcing the time, place, and date of the hearing, explaining how interested persons or organizations can request to participate in the hearing, and describing the hearing procedures. EPA conducts informal hearings in accordance with the procedures in 40 CFR part 750, subpart A.

II. Background

OSHA has published comprehensive requirements for protecting against the health effects of exposure to asbestos in the workplace. However, these requirements apply to employers in the private sector. OSHA has never had the authority to impose worker protection measures directly on State and local government employers. While a State

has the authority to protect State and local government employees under a State plan approved by OSHA under section 18 of the Occupational Safety and Health Act (OSH Act), 27 States do not do so. (Information regarding OSHA-approved State plans can be found at <http://www.osha-slc.gov/fso/osp/>.) EPA's WPR, 40 CFR part 763, subpart G, protects State and local government workers in States that do not have OSHA-approved State plans.

EPA determined when it first proposed the Worker Protection Rule in 1985 that asbestos exposures pose an unreasonable risk of harm to unprotected State and local government employees who conduct asbestos abatement projects, and that EPA has the authority under TSCA section 6 to establish asbestos worker protection standards for these employees (Ref. 1). In finalizing that proposal, EPA considered several options for protecting these workers from the risks of asbestos, including providing public information and technical assistance; deferring to the States; promulgating a regulation that provided greater protection than the then-current OSHA Asbestos Standard; and promulgating a regulation that followed the OSHA Standard to maintain consistency among Federal programs. EPA selected the last option, and implemented this selection in the WPR by setting out the OSHA requirements in full at 40 CFR part 763, subpart G (Ref. 2). In keeping with its policy of maintaining a consistent level of protection between the WPR and the OSHA Asbestos Standard, EPA amended the WPR in 1987 to incorporate recent changes to the Asbestos Standard that lowered the permissible exposure limit (PEL) to 0.2 fibers per cubic centimeter (f/cc) and that instituted new requirements for engineering and work practice controls and worker training (Ref. 3).

In response to further revisions to the OSHA Asbestos Standard for Construction (OSHA Construction Standard) (Refs. 4 through 6), EPA published proposed amendments to the WPR in the **Federal Register** of November 1, 1994 (Ref. 7). EPA's 1994 proposal would have made the WPR consistent with the 1990 version of the OSHA Construction Standards, and would have broadened the scope of the WPR to cover State and local government employees engaged in any form of construction work and in automotive brake and clutch repair. Shortly before EPA published its 1994 proposal, OSHA published major revisions to the OSHA Construction Standard and the OSHA Asbestos Standard for General Industry (OSHA

General Industry Standard) (Ref. 8). EPA responded to OSHA's new revisions by stating in its proposed amendments to the WPR that it intended to publish a separate rule to make the WPR consistent with OSHA's 1994 changes. Commenters on the 1994 EPA proposal generally disfavored this approach, suggesting that EPA propose all the changes necessary for consistency between the WPR and the OSHA Construction Standard in one rulemaking.

EPA agrees with the commenters and is therefore modifying its 1994 proposal to make the WPR consistent with the current OSHA Construction Standard, 29 CFR 1926.1101, including all revisions to that standard from 1994 through the present (Refs. 9 through 16). This proposal would also apply the current requirements of the OSHA General Industry Standard, 29 CFR 1910.1001, to State and local government employers of employees engaged in brake and clutch repair work, as did EPA's 1994 proposed rule. In addition, this proposal would extend the requirements of the General Industry Standard to general custodial activities that are not associated with construction projects.

In developing this proposal, EPA considered the comments submitted on its 1994 proposal and incorporated them where appropriate. A Response to Comments Document addresses these comments more fully (Ref. 17). It is included in the public version of the official record in the NCIC Docket described in Unit I.B.2.

A. What Action is the Agency Taking?

EPA is proposing to implement its long-standing policy of consistency between EPA's WPR and the OSHA Asbestos Standards by incorporating the 1994 revisions to the OSHA General Industry and Construction Standards into the WPR. Currently, employees working for some State and local governments are exposed to greater asbestos-related hazards in the work place than are employees working for private employers or other State and local governments. These additional hazards are not trivial, but instead expose these State and local government employees to meaningful additional risks that their colleagues working elsewhere are not asked to face. Fairness and equity dictate the same level of protection for all persons who work with asbestos-containing material (ACM), whether those persons are employed by the private sector or by a State or local government. Currently, all private sector workers, as well as State and local government employees in the

23 States that have OSHA-approved State plans, are protected by the more stringent OSHA regulations. The amendments in this proposed rule would create equity for the remaining State and local government workers by making the new, more stringent, OSHA requirements applicable to those workers.

This proposal would create that equity for the present and for the future by amending the WPR to cross-reference the OSHA General Industry and Construction Standards set out at 29 CFR 1910.1001 and 29 CFR 1926.1101 respectively, rather than by setting out the OSHA requirements in full at 40 CFR part 763, subpart G. Cross-referencing the OSHA Asbestos Standards in the WPR would mean that amendments to the OSHA General Industry or Construction Standard would have the effect of changing the requirements under the WPR as well. As such, State and local government employees would benefit from new OSHA provisions protecting workers against the risks of asbestos at the same time as private sector employees. Maintaining the same requirements for all workers dealing with asbestos would also avoid potential confusion and mistakes by allowing all workers and their supervisors to learn a single standard and know the requirements that apply to their work without additional training if such workers or supervisors move from the public sector to the private sector or vice-versa.

EPA invites comment on its policy that all State and local government employees be protected from the health risks of exposure to asbestos to the same extent as private sector workers. EPA also invites comment on whether it should use cross-referencing to achieve equitable protection for State and local government employees. Cross-referencing has the advantage of ensuring that changes in workplace standards take effect at the same time for both groups of workers. Without it, revisions to the OSHA Asbestos Standards could not take effect for State and local government employees until EPA had proposed and finalized amendments incorporating those revisions into the WPR. This would have the undesirable effect of creating a period in which the requirements of the WPR and of the OSHA Asbestos Standards would be inconsistent. Cross-referencing also has the advantage of deferring to OSHA's singular expertise in establishing standards in the field of worker protection.

It is within EPA's statutory authority and substantive expertise to find, under TSCA section 6, that the current amount

of exposure to asbestos in State and local government workplaces during use or disposal in construction, custodial, and brake and clutch repair work presents an unreasonable risk of injury to human health (see Unit II.B.1. for a detailed discussion of the basis for this finding), and to establish a policy of equitable protection from asbestos risks for State and local government employees. Moreover, TSCA section 9(d) requires EPA to consult and coordinate with other appropriate Federal agencies so as to achieve the maximum enforcement of TSCA while imposing the least burdens of duplicative requirements on regulated entities. EPA has therefore chosen to defer to OSHA's expertise and experience in setting workplace standards to protect workers from the risks of asbestos.

OSHA may, in the future, revise the Asbestos Standards. Cross-referencing would eliminate the need for a separate EPA rulemaking to amend the WPR, but State and local governments would still have the opportunity to participate in the rulemaking process. State and local governments with comments on specific worker protection measures could submit those comments directly to OSHA. State and local governments could also address comments to EPA asking that the Agency not adopt any new OSHA standard by filing a petition under TSCA section 21 requesting that EPA amend 40 CFR part 763, subpart G, to revise the cross-referencing structure. The petition should explain why EPA should depart from its longstanding policy of consistency and equity between the OSHA Asbestos Standards and the WPR, and should address EPA's rulemaking obligations under TSCA sections 6 and 9(d). In this context, adoption of the OSHA standard with the safeguard of the TSCA section 21 petition process allows the Agency to comply with the congressional intent evidenced in TSCA section 9 that EPA coordinate its activities under TSCA with the activities of other Federal agencies. When a TSCA section 21 petition is filed, EPA must respond within 90 days, either granting the petition and promptly initiating a rulemaking, or denying the petition and explaining its reasons for the denial.

Under the cross-referencing structure of this proposal, if you are a State or local government employer whose employees perform the construction and building maintenance activities identified in 29 CFR 1926.1101(a), and associated custodial work, you must comply with the OSHA Construction Standard, 29 CFR 1926.1101; if you are a State or local government employer

whose employees perform general custodial work or repair, cleaning, or replacement of asbestos-containing clutch plates and brake pads, shoes, and linings, or removal of asbestos-containing residue from brake drums or clutch housings, you must comply with the OSHA General Industry Standard, 29 CFR 1910.1001. This proposal would effectively alter State and local government employer obligations as follows:

1. *Expanded scope of coverage.* The current (1987) WPR applies solely to friable asbestos abatement projects. EPA has determined that there are substantial numbers of State and local government employees performing other construction, building maintenance, custodial, and brake and clutch repair activities. EPA has also determined that these employees will be exposed to unacceptably high levels of airborne asbestos fibers if they are not protected by an OSHA-approved State plan. See the Proposed WPR Economic Analysis (Economic Analysis) (Ref. 18). Therefore, as in 1994, EPA is proposing to expand the scope of the WPR to include all construction activities and custodial work involving ACM. This means that State and local government employees who remove non-friable ACM from buildings or perform building operations and maintenance tasks would be covered by the WPR. In addition, EPA is proposing to expand the scope of the WPR to include all brake and clutch repair work.

2. *Specific differences between the 1994 OSHA Standards and the current WPR*—a. *Classification scheme for asbestos construction projects.* In general, all of the requirements of the 1986 OSHA Construction Standard applied to all of the construction activities covered by the Standard. Projects of small-scale, short-duration were exempted from several of the provisions of the 1986 OSHA Standard, including those for negative pressure enclosures, competent person supervision, and decontamination areas. The current WPR likewise exempts small-scale, short-duration friable asbestos abatement projects from these requirements.

This proposed rule would amend the current WPR by cross-referencing the OSHA Construction Standard, which creates a classification scheme for all asbestos construction projects and related custodial activities except for the installation of new asbestos-containing materials (29 CFR 1926.1101(b)). This classification scheme reflects the fact that many different kinds of asbestos projects are regulated by the OSHA Construction Standard, and worker

protection needs may vary according to the type of project. The revised OSHA Construction Standard establishes the following four classes of asbestos projects, in descending order of risk:

- *Class I projects, involving removal of asbestos-containing, or presumed asbestos-containing, thermal system insulation (TSI) and surfacing materials.* Surfacing materials are materials that are sprayed or troweled or otherwise applied to surfaces. These materials include, for example, decorative plaster, acoustical material on decking, and fireproofing on structural members. TSI includes material applied to pipes, boilers, tanks and ducts. According to OSHA, these projects require the most stringent of controls, due to the prevalence of these materials and the likelihood of significant fiber release when disturbing them. Class I projects are regulated by the current WPR because they involve friable ACM.

- *Class II projects, involving removal of all other ACM or presumed ACM.* These projects involve materials such as floor or ceiling tiles and wallboard, which are referred to as “miscellaneous ACM” in EPA’s Asbestos-in-Schools Rule (40 CFR 763.83), and other ACM on the exterior of buildings such as siding and roofing. Most Class II projects are not covered by the current WPR, since they involve non-friable ACM. This proposal would extend coverage of the WPR to all Class II projects.

- *Class III projects, repair and maintenance activities involving the intentional disturbance of ACM or presumed ACM.* Removal of ACM or presumed ACM under Class III is limited to the incidental removal of a small amount of material, for example, in order to repair a pipe or to access an electrical box. Class III projects involving friable ACM are generally regulated under the current WPR as small-scale, short-duration asbestos abatement projects.

- *Class IV activities, maintenance and custodial activities where employees contact ACM and presumed ACM.* These projects involve activities such as the repair or replacement of ceiling tiles, repair or adjustment of ventilation or lighting, dusting of surfaces, mopping of floors, or vacuuming of carpets. Class IV activities may also include sweeping, mopping, dusting, or vacuuming incidental to a Class I–III regulated project. Most Class IV projects are not covered by the current WPR because they are not considered to be asbestos abatement projects.

Some of the requirements (for example, the PELs, specified work

practices and engineering controls, supervision by a competent person, and, in certain circumstances, regulated areas and training) apply to all construction projects and related custodial activities covered by the standard, including installation of new asbestos-containing materials. Work practices and engineering controls applicable to all projects include the use of wet methods (where feasible), HEPA vacuums, and, if necessary, ventilation systems to achieve compliance with the required PELs. All projects must be supervised by competent persons, but the training requirements for Class III and Class IV supervisors are much less stringent than for those persons supervising Class I and Class II projects.

Beyond these basic requirements, the current OSHA work practice and engineering control requirements are specific to each class of project and, for Class II projects, specific to the type of material being removed. These requirements are discussed in more detail under the heading “Methods of compliance for construction projects and associated custodial activities” in Unit II.A.2.h.

b. *Hazard communication.* This proposal would adopt the provisions from the OSHA General Industry and Construction Standards for the identification of asbestos hazards by building owners and employers and the communication of hazard information among building owners, employers, employees, and tenants (29 CFR 1910.1001(j), 29 CFR 1926.1101(k)). Under these Standards, building owners and employers must identify the presence, location, and quantity of ACM in the worksite before work begins. Any TSI and surfacing materials in buildings constructed earlier than 1981 must be presumed to contain asbestos, unless a person with the appropriate qualifications determines, in accordance with recognized sampling and analytical methods, that the material does not contain asbestos.

If the material to be analyzed is in a school or a public or commercial building, then EPA’s Model Accreditation Plan (MAP) requires the sampling to be done by a person accredited as an inspector under the MAP (40 CFR part 763, subpart E, Appendix C). If the material is not in a building regulated by the MAP, e.g., it is on an outdoor installation, either a MAP-accredited inspector or a Certified Industrial Hygienist may perform the sampling. Resilient floor covering installed prior to 1981 must also be presumed to contain asbestos unless an industrial hygienist or a MAP-accredited inspector determines through

recognized analytical techniques that it does not contain asbestos. Again, if the material to be sampled is in a building regulated by the MAP, then the sampling must be done by a MAP-accredited inspector.

Results obtained during an inspection that complies with the Asbestos-in-Schools Rule requirements at 40 CFR 763.85(a) are sufficient to rebut the presumption that TSI, surfacing material, or resilient floor covering contains asbestos. Although not required by the OSHA Standards or the EPA MAP, bulk samples taken from school buildings regulated by the Asbestos Hazard Emergency Response Act (AHERA) must be analyzed by laboratories accredited by the National Institute of Standards and Technology (NIST). For a fuller discussion on the hazard communication provisions, see the OSHA preamble in the **Federal Register** of August 10, 1994 (Ref. 8, p. 41013).

Under these proposed amendments to the WPR, State and local government entities whose employees perform asbestos-related construction, custodial, or brake and clutch repair work would be required to determine the presence, location and quantity of ACM or presumed ACM in the worksite. Although EPA recommends that State and local governments make this determination based upon a full building inspection done by a MAP-accredited inspector, the minimum requirement is to identify three types of building materials (TSI, surfacing material, and resilient floor covering) that must be presumed to contain asbestos. EPA believes that the identification of types of building materials does not require the expertise of a MAP-accredited inspector, since no judgment as to asbestos content is being made. However, if there is some reason to suspect that other materials in the worksite may contain asbestos, or the employer wishes to rebut the presumption of asbestos content, and the project will be taking place within a public or commercial building, then the services of a MAP-accredited inspector will be required.

This proposal would then require State and local government employers to provide their own employees, and other on-site public and private employers, with information on the presence, location and quantity of ACM and presumed ACM in the worksite, along with specific details on the nature of the activity to be performed, requirements pertaining to regulated areas, and the measures that will be taken to prevent exposure to adjacent workers.

Although the hazard communication provisions of the OSHA Standards apply to building owners as well as employers, EPA is not proposing to extend these requirements to State and local government building owners who are not also employers. EPA believes that, in most cases, the employer and the building owner will be the same, i.e., both will be State agencies, or City agencies. If the building owner and the employer are the same, then a separate provision imposing identification and communication obligations on the building owner is unnecessary. EPA requests comment on the extent to which this assumption may be incorrect.

c. Project notifications. EPA is proposing to remove the current requirement that employers who plan an asbestos abatement project notify EPA at least 10 days in advance (40 CFR 763.124). In 1994, OSHA considered and rejected a requirement for employers to report all asbestos projects, except those of small-scale, short-duration, in advance. OSHA's decision was based on the fact that, since there are other existing Federal and State reporting requirements, additional reporting requirements in the OSHA Construction Standard would be burdensome for the employer without enhancing compliance. For a comprehensive discussion of OSHA's reasoning, see the **Federal Register** of August 10, 1994 (Ref. 8, pp. 40970–40971). EPA agrees with this logic, since it is easily able to use reports received under the asbestos National Emission Standard for Hazardous Air Pollutants (NESHAP) regulations, 40 CFR part 61, subpart M, to target worker protection inspections. Two commenters on the 1994 proposed amendments to the WPR argued that EPA should be consistent with OSHA on this subject. In addition, several other commenters noted that the notification requirement would become extremely burdensome with the increased number of projects covered by the expansion of the scope of the rule to non-friable removal projects and maintenance (Ref. 17). EPA would, however, adopt the OSHA reporting requirements for Class I alternative control methods as discussed under the heading "Methods of compliance for construction projects and associated custodial activities" in Unit II.A.2.h.

d. Permissible exposure limits. This proposed amendment to the WPR would lower the PEL of 0.2 f/cc to 0.1 f/cc as an 8-hour, time-weighted average, OSHA's current PEL for all covered activities. 29 CFR 1910.1001(c), 29 CFR 1926.1101(c). In 1994, OSHA lowered its PEL from 0.2 f/cc to 0.1 f/cc. For a

comprehensive discussion of OSHA's findings see the **Federal Register** of August 10, 1994 (Ref. 8, pp. 40978–40982). This proposal also retains a provision included in the 1994 proposed WPR amendments under which employees would be protected by a short-term excursion limit of 1.0 f/cc for a 30 minute sampling period. EPA did not receive any comments on this proposed excursion limit. Finally, EPA proposed in 1994 to allow employers to use an alternative PEL based upon results of Transmission Electron Microscopy (TEM). Several commenters stated that the proposed alternative PEL was not adequately supported by science (Ref. 17), so EPA is withdrawing that portion of its 1994 proposal.

e. Multi-employer worksites. The current WPR requires State and local government employers to communicate information about the nature of asbestos work and regulated area requirements to other employers, whether public or private, on multi-employer worksites (40 CFR 763.121(d)). This proposal would adopt by cross-reference the requirements of 29 CFR 1926.1101(d) of the OSHA Construction Standard for multi-employer worksites where construction and related custodial work is being performed. The OSHA Construction Standard requires employers whose employees are performing construction and associated custodial activities within regulated areas to provide other on-site employers with information concerning the nature of the asbestos-related work, information on regulated areas, and information on the specific measures that will be taken to prevent exposure to other employees. In addition, this provision of the OSHA Construction Standard clarifies that while the employer who creates an asbestos hazard must abate it, other on-site employers are responsible for protecting their employees from the hazard by removing them from the area or conducting an exposure assessment and providing personal protective equipment if warranted.

f. Regulated areas. Under the current WPR, employers must establish a regulated area where employee exposures on asbestos abatement projects exceed, or are expected to exceed, the PEL, and all persons entering regulated areas must wear respirators (40 CFR 763.121(e)). This proposal, by cross-referencing the OSHA General Industry Standard, would make these requirements applicable to State and local governments who employ brake and clutch repair workers (29 CFR 1910.1001(e)).

This proposal, by cross-referencing 29 CFR 1926.1101(e) of the OSHA Construction Standard, would also require all Class I-III asbestos construction work to be conducted within a regulated area. This requirement is based upon OSHA's assessment of the construction activities most likely to produce exposures in excess of the PEL, as well as OSHA's concern with the significant risk that still remains for workers exposed to the PEL. OSHA's reasoning is discussed in the **Federal Register** of August 10, 1994 (Ref. 8, p. 40982). Although this proposal would require State and local government employers to establish, demarcate, and control access to regulated areas for most asbestos construction work, construction employees working within regulated areas would not automatically need to wear respirators unless otherwise required by the regulation.

g. *Exposure monitoring.* The current WPR requires employers to perform initial employee exposure monitoring for each covered activity, unless the employer has historical data from similar operations showing exposures below the PEL, or the employer can produce objective data showing that the material involved cannot release asbestos fibers in excess of the action level of 0.1 f/cc (40 CFR 763.121(f)). With respect to employees performing construction activities and associated custodial work, this proposal, by cross-referencing the OSHA Construction Standard, would modify the requirements for initial and periodic monitoring to reflect increased awareness that numerous factors influence employee exposure on construction jobs and that initial monitoring alone may not be the best predictor of future exposures. For more information on these considerations, see the **Federal Register** of August 10, 1994 (Ref. 8, pp. 40983-40984).

The OSHA Construction Standard requires a competent person to make an initial exposure assessment (29 CFR 1926.1101(f)). This assessment involves a review of initial monitoring data, previous monitoring data from the same workplace or employer, and other factors such as the training and experience of the employees who will perform the work, the work practices they will use, and the degree and quality of supervision that will be provided. In many cases, the competent person will be able to make a negative exposure assessment, a determination that employee exposures will be consistently below the PELs, based upon one of three things:

- Objective data which demonstrate that the product or activity involved is incapable of producing airborne asbestos concentrations in excess of the PELs.
- Recent monitoring data from previous asbestos jobs which closely resemble the current activity with respect to processes, material types, control methods, work practices, environmental conditions, and employee training and experience.
- Initial monitoring data from the current asbestos job.

Unless a negative exposure assessment can be made, the employer must conduct daily exposure monitoring to ensure compliance with the exposure limits.

For general custodial work and brake and clutch repair activities, this proposal would, by cross-referencing the OSHA General Industry Standard, require air monitoring only for activities where exposures exceed, or can reasonably be expected to exceed a PEL, and the employer does not have historical data from similar operations or objective data concerning the material which indicates that exposures will be below the PEL (29 CFR 1910.1001(d)).

h. *Methods of compliance for construction projects and associated custodial activities.* This proposal cross-references the OSHA Construction Standard requirements for engineering controls and work practices (29 CFR 1926.1101(g)). Where necessary to achieve the PEL, the current WPR requires one or more of the following: HEPA vacuums, wet methods where feasible, and prompt cleanup and disposal of asbestos-containing waste and debris. These three general control processes would become mandatory under this proposal for all asbestos construction work. The remaining control processes mentioned in the existing 40 CFR 763.121(g), local exhaust ventilation, general ventilation systems, and enclosure/isolation of dust-producing processes, are only required by the OSHA Construction Standard where necessary to achieve the PELs.

Under the current WPR, employers are required, if feasible, to use negative pressure enclosures for all projects that are not of small-scale, short-duration (40 CFR 763.121(e)(6)). For Class I projects, this proposal would cross-reference the OSHA Construction Standard, which gives employers the flexibility to choose, depending upon the type of project, from several different engineering control systems, including negative pressure enclosures, glove bags, negative pressure glove bag

systems, negative pressure glove box systems, water spray process systems, or mini-enclosures (29 CFR 1926.1101(g)). Alternative control methods may be used, so long as a competent person is able to certify that the methods would be adequate to reduce employee exposures below the PEL and that asbestos contamination beyond the regulated area will not occur. If the Class I project involves more than 25 linear or 10 square feet of ACM, this determination must be made by a certified industrial hygienist or a licensed professional engineer who is also qualified as a project designer, and the Director, National Program Chemicals Division, Office of Pollution Prevention and Toxics, EPA, must be notified in advance. Additional requirements for Class I projects include critical barriers, or other methods to prevent the migration of fibers off-site, impermeable drop cloths for surfaces, and sealing of the HVAC system.

Class II projects are generally not covered by the current WPR unless they involve friable ACM or previously non-friable ACM which has become damaged to the point that it can be considered friable. This proposal, like the 1994 proposal, would extend coverage of the WPR to all construction work involving ACM, whether friable or non-friable. This proposal would cross-reference the OSHA Construction Standard which, in addition to the basic control requirements for all construction work, requires employers to follow specific work practices and use specific engineering controls for different types of ACM, including resilient floor coverings, roofing material, cementitious siding and transite panels, and gaskets. For example, with respect to the removal of resilient floor coverings, 29 CFR 1926.1101(g)(8)(i) prohibits sanding of flooring or backing, rip-up of resilient sheet material, and dry sweeping/scraping. In addition, mechanical chipping of resilient floor covering is prohibited unless it is performed in accordance with the requirements for Class I projects. For all specified Class II projects, critical barriers or other isolation methods must be used, and the surfaces must be covered with impermeable drop cloths. As with Class I projects, Class II projects may be conducted with alternative control methods, as long as a competent person evaluates the project area and certifies that the alternative controls are sufficient to reduce employee exposure below the PELs. For Class II projects, however, the employer is not required to notify the Agency.

Many Class III activities are currently covered by the WPR as small-scale,

short-duration asbestos abatement projects. Several of the control methods required by 29 CFR 1926.1101(g)(9) of the OSHA Construction Standard for Class III projects (wet methods, local exhaust ventilation as feasible, and, under specified circumstances, impermeable drop cloths and isolation methods) are essentially the same as the current WPR requirements in 40 CFR 763.121(g). If, for a particular Class III project, the employer is unable to produce a negative exposure assessment or monitoring results show the PEL has been exceeded, the OSHA Construction Standard requires the employer to use impermeable drop cloths and plastic barriers or their equivalent or one of the listed Class I control methods, such as a negative pressure enclosure or a glove bag.

Class IV activities are not currently covered by the WPR. This proposal would extend the scope of the WPR to cover Class IV activities. In addition, this proposal would cross-reference the OSHA Construction Standard, which requires employers conducting Class IV activities to use general control measures, such as wet methods, HEPA vacuums, and prompt cleanup (29 CFR 1926.1101(g)(10)). However, employees performing Class IV activities must be provided with respirators if they are performing housekeeping activities in a regulated area where other employees are wearing respirators.

i. *Methods of compliance for brake and clutch repair activities.* This proposal would require State and local government employers whose employees perform brake and clutch repair activities to comply with the OSHA General Industry Standard. In addition to general worker protection provisions, such as PELs, exposure monitoring, and respiratory protection, the OSHA General Industry Standard requires employers to use one of two primary methods for controlling employee exposure to asbestos during brake and clutch repair (Appendix F to 29 CFR 1910.1001).

The Negative Pressure Enclosure/HEPA Vacuum System method requires the work to be performed within a sealed enclosure similar to a glove bag, with impermeable sleeves through which the worker may handle brake and clutch components. Negative pressure must be maintained within the enclosure while the work is being performed. This method is virtually identical to the Enclosed Cylinder/HEPA Vacuum method in EPA's 1994 proposal, but OSHA changed the name of this method to reflect the fact that the enclosure does not necessarily have to be in the shape of a cylinder. The Low

Pressure/Wet Cleaning method requires the brake and clutch components to be kept adequately wet, using a low pressure water flow and a catch basin, while repair activities are taking place. Employers whose employees perform 5 or fewer brake and clutch repair jobs per week may use less complex wet methods to control employee exposures during the projects. An employer could use an alternative control method if the method was demonstrated to control employee exposures at least as well as the Negative Pressure Enclosure/HEPA Vacuum method.

j. *Methods of compliance for general custodial activities.* This proposal would require State and local government employers whose employees perform custodial activities not associated with construction projects to comply with the OSHA General Industry Standard. In addition to general worker protection provisions, such as PELs, exposure monitoring, and respiratory protection, the OSHA General Industry Standard and Construction Standard contain identical specifications for resilient floor covering maintenance. The Standards ban sanding, allow stripping only using wet methods with a low abrasion pad at slow speeds, and prohibit dry buffing unless the finish on the floor is sufficient to prevent the pad from coming into contact with the floor material (29 CFR 1910.1001(k)(7), 29 CFR 1926.1101(l)(3)). This is generally consistent with EPA's existing guidance on floor maintenance (Ref. 19).

k. *Respirators.* The current WPR requires employers to supply respirators to employees entering regulated areas (40 CFR 763.121(e)(4)). This proposal would cross-reference the OSHA General Industry and Construction Standards (29 CFR 1910.1001(e), 29 CFR 1926.1101(h)), which require respiratory protection for employees performing the following activities:

- Class I projects.
- Class II projects where ACM is not removed intact.
- Class II–III projects that do not use wet methods.
- Class II–III projects for which a negative exposure assessment has not been made.
- Class III projects involving the disturbance of TSI or surfacing material.
- Class IV work in regulated areas where other employees are wearing respirators.
- Any other activities where asbestos exposure exceeds either of the PELs.
- Emergencies.

OSHA determined that respiratory protection was necessary for employees performing these activities due to the

variability in exposures experienced during asbestos work, the need to protect workers who are disturbing ACM with the greatest potential for significant fiber release, and the fact that exposure monitoring results are not always available in a timely fashion. OSHA's findings are discussed in the **Federal Register** of August 10, 1994 (Ref. 8, p. 41010).

In addition, EPA's 1994 proposed amendments to the WPR cross-referenced the relevant portions of 29 CFR 1910.134, the OSHA Respiratory Protection Standard. In 1998, OSHA substantially revised this Standard (Ref. 14). This proposal would adopt by cross-reference the appropriate provisions of the revised OSHA Respiratory Protection Standard. The following is a discussion of requirements of the OSHA Respiratory Protection Standard that are not a part of the current WPR respirator requirements.

Employers who are required to supply their employees with respirators must develop and implement a respiratory protection program. Under 29 CFR 1910.134(c), the program must be in writing, updated as necessary, with workplace-specific procedures addressing the following major elements:

- Procedure for selecting respirators.
- Medical evaluations of employees required to use respirators.
- Fit testing procedures for tight-fitting respirators.
- Procedures for proper use of respirators in routine and (reasonably foreseeable) emergency situations.
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators.
- Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators.
- Training of employees in the respiratory hazards they are potentially exposed to.
- Training of employees in proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance.
- Procedures for regularly evaluating program effectiveness.

Employers must designate a person to administer and evaluate the respiratory protection program (29 CFR 1910.134(c)(3)). This administrator must have training and/or experience commensurate with the complexity of the particular program.

Under 29 CFR 1910.134(d), the employer must provide respirators that are appropriate to the workplace and to

user factors that affect respirator performance and reliability, such as humidity, communication needs, and exertion levels. (See discussion at Ref. 14, p. 1196.) The employer must choose from a sufficient number of respirator models and sizes in order to properly fit the wearer (29 CFR 1910.134(f)).

Currently, the WPR requires an initial fit test, then, for negative-pressure respirators only, fit tests every 6 months (40 CFR 763.121(h)(4)). By adopting the OSHA Respiratory Protection Standard by cross-reference, this proposal would lengthen the interval to a year, but periodic fit test would be required for all tight-fitting respirators, whether positive or negative pressure. As in the current WPR, fit testing would have to be accomplished using one or more OSHA-approved protocols. In addition to the rigorous fit testing requirements, the OSHA Respiratory Protection Standard requires brief, easy-to-perform fit checks each time the respirator is worn (29 CFR 1910.134(g)(1)(iii)). (See discussion at Ref. 14, p. 1239.)

The OSHA Respiratory Protection Standard at 29 CFR 1910.134(h) requires specific respirator cleaning and maintenance practices, although an employer may choose to follow the instructions of the respirator manufacturer if they are sufficient to accomplish the same objectives such as sanitation and proper operation. The specific practices to be incorporated were compiled by OSHA from various sources, including recommendations by the American National Standards Institute (ANSI), the National Institute for Occupational Safety and Health (NIOSH), and the American Industrial Hygiene Association (AIHA).

Employees must be trained in specific elements of proper respirator use and care, including the need for respirators, their limitations, emergency procedures, maintenance, inspection, storage, and medical signs and symptoms that may limit respirator effectiveness (29 CFR 1910.134(k)).

Finally, 29 CFR 1910.134(m) requires employers to keep records of employee fit tests, including the employee's name, the type of test, the specific make/model of respirator tested, the date of the test, and the results of the test. The employer must only retain the most recent fit test records for each employee.

1. *Protective clothing.* The current WPR requires properly maintained and laundered protective clothing for employees exposed above the PEL (40 CFR 763.121(i)). This proposal would adopt the OSHA General Industry and Construction Standards, which require protective clothing to be provided where employees are exposed above the

PELs, where the possibility of eye irritation exists, where a negative exposure assessment cannot be made for a particular project, or where employees are performing Class I operations involving the removal of over 25 linear or 10 square feet of TSI or surfacing ACM or PACM (29 CFR 1910.1001(h), 29 CFR 1926.1101(i)). In addition, rather than the periodic inspections required by the current WPR, the Construction Standard requires the competent person to inspect employee worksuits at least once each shift for rips or tears.

m. *Hygiene facilities and practices.* This proposal would adopt the hygiene requirements of the OSHA General Industry and Construction Standards (29 CFR 2910.1001(i), 29 CFR 1926.1101(j)). For Class I construction projects involving more than 25 linear or 10 square feet of ACM, the OSHA requirements are identical to the current WPR provisions for projects that are not of small-scale, short-duration (40 CFR 763.121(j)). OSHA determined in 1994 that such stringent measures were not necessary for smaller Class I projects or other classes of construction work. For smaller Class I projects, and Class II and III projects where exposures exceed a PEL or where a negative exposure assessment is not produced, the employer must provide an equipment room or area where contaminated worksuits are HEPA-vacuumed and then removed. Again, if Class IV workers are performing housekeeping activities within a regulated area, they must follow the same hygiene practices as the other employees working in that area. For general custodial workers and brake and clutch repair workers, the OSHA General Industry Standard, which would be adopted by cross-reference, requires employers to provide clean change rooms, showers, and clean lunch rooms (29 CFR 1910.1001(i)). For all workers, this proposal would also adopt, by cross-reference, OSHA's ban on smoking in work areas that was proposed by EPA in 1994 (29 CFR 1910.1001(i)(4), 29 CFR 1926.1101(j)(4)).

n. *Communication of hazards.* This proposal would adopt by cross-reference the requirement in the OSHA General Industry and Construction Standards that employers determine the presence, location, and quantity of ACM and presumed ACM (TSI, surfacing material, and resilient floor covering) in the worksite before work begins (29 CFR 1910.1001(j), 29 CFR 1926.1101(k)). If ACM or presumed ACM is discovered in the worksite after the project has been started, the employer must inform other on-site employers of the discovery.

Under the OSHA Standards, employers must also post signs at the

entrance to mechanical rooms that contain ACM or presumed ACM. These signs must identify the material, its location, and appropriate procedures for preventing a disturbance. As currently required by the WPR at 40 CFR 763.121(k)(1)(i), signs must be posted for regulated areas, but the OSHA Standards language regarding respirators and protective clothing may be omitted if the employees are not required to wear them within that particular regulated area. The OSHA Standards include the requirement proposed by EPA in 1994 that employers ensure their employees comprehend the warning signs and labels, using, if necessary, such techniques as foreign languages, pictographs, graphics, and awareness training (29 CFR 1910.1001(j)(3), 29 CFR 1926.1101(k)(3)).

Also, by cross-referencing the OSHA Construction Standard, this proposal would adopt the different OSHA training requirements for different classes of construction work and associated custodial activities (29 CFR 1926.1101(k)(9)). Under the OSHA Construction Standard, employees performing Class I projects must have MAP worker accreditation or the equivalent. If the project will be undertaken in a school or a public or commercial building, MAP worker accreditation is required. If the project is in an area unregulated by the MAP, such as in an outdoor installation, equivalent training is permitted. Class II work generally involves non-friable ACM, so MAP accreditation is not required unless the project involves friable ACM and is located within a school or a public or commercial building. The OSHA Construction Standard requires Class II workers to receive training in the material-specific work practice and engineering control requirements pertaining to the type of material(s) that they will be disturbing. Class II training must take at least 8 hours and include a hands-on component. Class III workers must have 16 hours of training in a course which meets the requirements of the maintenance and custodial training required under the AHERA regulations at 40 CFR 763.92(a)(2). Class IV workers must have at least two hours of awareness training equivalent to the training described in the AHERA regulations at 40 CFR 763.92(a)(1). Notwithstanding the specific training provisions for each class, the OSHA Construction Standard at 29 CFR 1926.1101(k)(9) requires employers to ensure that employees performing Class I-IV projects and employees who are

likely to be exposed in excess of the PEL are trained in the basic elements currently identified in the WPR at 40 CFR 763.121(k)(3)(iii).

The OSHA Construction Standard also includes the requirements to provide employees with smoking cessation information as well as information concerning posting signs and affixing labels and their meaning that were proposed by EPA in 1994 (29 CFR 1926.1101(k)(9)(viii)(j)). Finally, the OSHA Construction Standard requires employers to teach Class III–IV workers the contents of “Managing Asbestos In Place” (the Green Book) (EPA 20T–2003, July 1990), or its equivalent (29 CFR 1926.1101(k)(9)(viii)(D)).

With regard to training for general custodial employees and brake and clutch repair workers, this proposal would adopt the OSHA General Industry Standard, which includes required training elements similar to those found in the current WPR (29 CFR 1910.1001(j)(7), 40 CFR 763.121(k)(3)(iii)).

o. Housekeeping. By adopting the OSHA General Industry and Construction Standards by cross-reference, this proposal would establish requirements for resilient floor covering maintenance by State and local government employees. The Standards ban sanding, allow stripping only using wet methods with a low abrasion pad at slow speeds, and prohibit dry buffing unless the finish on the floor is sufficient to prevent the pad from coming into contact with the floor material (29 CFR 1910.1001(k)(7), 29 CFR 1926.1101(l)(3)). The Standards are generally consistent with EPA’s existing guidance on floor maintenance (Ref. 19).

p. Medical surveillance. The WPR currently requires medical surveillance for persons exposed at or above the action level of 0.1 f/cc for 30 or more days per year (40 CFR 763.121(m)). For general custodial workers and brake and clutch repair workers, this proposal would adopt by cross-reference the OSHA General Industry Standard requirement for medical surveillance for all workers exposed to asbestos concentrations at or above the PELs for any number of days per year (29 CFR 1910.1001(l)). For construction workers, this proposal would require, by cross-reference to the OSHA Construction Standard, medical surveillance for employees who perform Class I, II, or III work on, or who are exposed at or above a PEL for, 30 or more days per year (Class II or III work for an hour or less on intact ACM does not count as a day for the purposes of this requirement) (29 CFR 1926.1101(m)(1)(i)(A)).

q. Recordkeeping. The current WPR recordkeeping requirements would not be changed by this proposal, except that data used to rebut the presumption that TSI, surfacing material, or resilient floor covering is ACM must be retained by the employer for as long as the data are relied upon to rebut the presumption (40 CFR 763.121(n); 29 CFR 1919.1001(m); 29 CFR 1926.1101(n)). This proposal would also permit employers to use competent organizations to maintain necessary records.

r. Competent person. The current WPR requires a competent person to supervise asbestos abatement projects that are greater than small-scale, short-duration activities (40 CFR 763.121(e)(6)). The OSHA Construction Standard at 29 CFR 1926.1101(o), which this proposal would adopt by cross-reference, extends the competent person supervision requirement to all construction projects and associated custodial work. The Construction Standard also expands and clarifies the responsibilities and required training for competent persons. Competent persons who supervise Class I or Class II projects must be MAP-accredited contractor/supervisors or the equivalent. Equivalent training is permitted unless the project being supervised involves friable material in a school or a public or commercial building. Competent persons who supervise Class III or Class IV activities must have at least 16 hours of training which meets the requirements of 40 CFR 763.92(a)(2) for local education agency maintenance and custodial staff, or its equivalent in stringency, content and length. The competent person must make regular inspections of the worksite, at least once per workshift for Class I projects, and must also be available for inspections upon request. Competent persons are generally responsible for ensuring compliance with the various regulatory requirements, including notifications and initial exposure assessments. The competent person requirements do not apply to brake and clutch repair operations or to general custodial activities not associated with construction projects.

3. Proposed amendment to the Asbestos-in-Schools Rule. As in 1994, EPA is again proposing to amend the Asbestos-in-Schools Rule to remove the provisions that extend WPR protections to employees of public school systems when they are performing operations, maintenance and repair (O&M) activities (40 CFR 763.91(b)). The expanded scope of the proposed WPR would make these provisions unnecessary.

The current WPR covers State and local government employees, including employees of public schools who are involved in friable asbestos abatement projects. The Asbestos-in-Schools Rule (40 CFR part 763, subpart E), issued under the authority of AHERA, extends WPR protections to employees of public local education agencies when they are performing small-scale, short-duration O&M activities involving asbestos-containing materials. Appendix B to the Asbestos-in-Schools Rule describes appropriate worker protection practices for these employees.

Since this proposal would provide coverage for all construction work, including O&M activities, to employees of public local education agencies in States without OSHA-approved State plans, the specific provisions at 40 CFR 763.91(b) covering O&M activities by employees of public local education agencies, as well as the provisions of Appendix B, would be unnecessary. EPA is therefore proposing to delete Appendix B and amend § 763.91(b) to refer readers to the WPR.

4. Plain language. EPA has drafted the revised regulatory text of the WPR taking into account the June 1, 1998, Presidential Memorandum on Plain Language (available at <http://www.plainlanguage.gov/cites/memo.htm>), and its implementing guidance. Using plain language clarifies what the WPR requires, and saves the government and the private sector time, effort, and money. EPA has used plain language to give the WPR a logical organization and easy-to-read design features. In the process, EPA has deleted from the proposed rule the current sections on enforcement and inspections (40 CFR 763.125 and 763.126). These sections are unnecessary, as they restate requirements in TSCA sections 11, 15, 16, and 17. Accordingly, EPA will continue to enforce the WPR and conduct inspections.

5. State exemptions. The 1994 proposal would have revised § 763.122 to adopt a process of State exclusions from the WPR that was substantively the same as that followed under the Asbestos-in-Schools Rule (40 CFR 763.98). EPA has re-examined its authority under TSCA section 18, and is not including those changes in this proposed rule. Instead, EPA is proposing to revise the current language to conform to TSCA section 18 and to use plain language. This proposal would also redesignate this section as § 763.123 because of other structural changes to 40 CFR part 763, subpart G.

B. What is the Agency's Authority for Taking this Action?

1. Finding of unreasonable risk.

Under TSCA section 6(a), if EPA finds that the manufacture, processing, distribution in commerce, use or disposal of a chemical substance or mixture, or any combination of these activities, presents, or will present, an unreasonable risk of injury to health or the environment, EPA shall by rule apply requirements to the substance or mixture to the extent necessary to protect adequately against the risk. Asbestos is a chemical substance or mixture that falls within the scope of this authority. In deciding whether to propose this rule under TSCA section 6(a), EPA considered:

- The health effects of asbestos.
- The magnitude of human exposure to asbestos.
- The environmental effects of asbestos and the magnitude of the exposure of the environment to asbestos.
- The benefits of asbestos for various uses and the availability of substitutes for those uses.
- The reasonably ascertainable economic consequences of the proposed rule, after consideration of the effect on the national economy, small business, technological innovation, the environment, and public health.
- The social impacts of the proposed rule.

See 15 U.S.C. 2601(c) and 2605(c)(1). EPA's consideration of these factors in proposing this rule is summarized in this unit. Additional information on many of these factors can be found in the Economic Analysis (Ref. 18).

a. Health effects of asbestos. Asbestos is found in building products such as insulation, ceiling and floor tiles, spackling tape for drywall, and roofing products. In general, asbestos contained in such products is considered harmless unless the matrix of asbestos fibers is disturbed or deteriorates. A disturbance occurs when ACM is abraded, cut, torn or penetrated in such a way that fibers are separated from one another and are released into the air where workers and others can inhale them. The primary route of human exposure is through the respiratory system, although other exposure routes (through ingestion or dermal contact, for example) are possible. Five respiratory illnesses are associated with asbestos exposure.

• *Carcinoma of the lung (lung cancer).* Carcinoma of the lung is a term used to refer to several types of cancer of lung tissue. The cancers usually affect the larger airways in the lungs, but may sometimes also appear in the smaller

airways and peripheral parts of the lungs. Asbestos-related lung cancer occurs primarily in people with some degree of asbestosis (especially moderate to severe asbestosis) who also smoke. The combination of asbestos exposure and smoking is between additive and multiplicative; some studies cite a 5-fold increase in the risk of lung cancer in asbestos-exposed nonsmokers versus a 60-fold increase in asbestos-exposed smokers. Lung cancer usually occurs many years after asbestos exposure, and is nearly always fatal.

• *Malignant mesothelioma of the pleura and peritoneum.* Mesothelioma is a form of cancer that produces malignancies in the lining of the lung and chest cavity (pleura) and the lining of the abdominal organs and cavity (the peritoneum). The disease appears to be largely or wholly unrelated to smoking. Unlike lung cancer, which occurs in asbestos-exposed and unexposed smokers alike, malignant mesotheliomas occur mainly in asbestos-exposed individuals. Like lung cancer, mesothelioma usually occurs many years after exposure, and is always fatal. Mesothelioma is much less common than lung cancer, representing about 10% of lung cancer incidents.

• *Asbestosis.* Asbestosis is a chronic and progressive lung disease caused by inhaling asbestos fibers, which penetrate and irritate the outer parts of the lungs. This, in turn, causes inflammation and, eventually, increasingly severe pulmonary fibrosis (thickening and scarring of lung tissue). As the tiny airways, air sacs, and related lung tissue become thicker and scarred, there is less space for air to pass through, so lung capacity declines. In addition, the lung tissue stiffens, making it more difficult to push air in and out. In the extreme, extensive fibrosis of the lungs causes the airways and air sacs to become so scarred and stiff that they cannot function well enough to sustain life, and respiratory failure and death ensue. The time from asbestos exposure to onset of asbestosis varies with the level of exposure, with higher exposures reducing the time till onset. Asbestosis will exacerbate other respiratory diseases (e.g., carcinoma of the lung) and will hasten death in individuals with other respiratory risk factors (i.e., smokers).

• *Pleural effusion leading to diffuse pleural thickening.* Inhalation of asbestos fibers can lead to pleural conditions as the fibers become trapped on the pleural membranes. Asbestos-related pleural effusion is an accumulation of fluid between the two pleural membranes caused when asbestos fibers become trapped between

the pleural membranes. One pleural membrane lines the lungs, while the other membrane lines the chest cavity. Normally, the two membranes lie very close to each other, sliding gently across each other during breathing.

Accumulation of fluid causes the membranes to separate in the area of the fluid, usually making breathing more difficult and painful. Pleural effusion can cause the pleural membranes to thicken from irritation and infiltration of immune cells. Occasionally, the pleural membranes may fold in on themselves, crowding and trapping a piece of lung tissue. The resulting condition, called rounded atelectasis, is more likely to be symptomatic, but nevertheless is fairly benign, although the folding and lung tissue trapping can become larger over time, decreasing lung capacity and leading to shortness of breath. Pleural effusion usually occurs 10 to 15 years after continuous exposure to asbestos, and is rarely fatal.

• *Pleural plaques.* Deposits of asbestos fibers on the pleural membrane can sometimes become calcified, forming asbestos-related pleural plaques. Local areas of pleural thickening resemble pleural plaques and have similar clinical features. Pleural plaques are more common in overweight people, including many smokers. By causing portions of lung tissue to stiffen, they can impair lung function, making it harder to breathe, especially during exertion. In general, though, they are relatively benign and rarely fatal. Pleural plaques occur approximately 10 to 15 years after asbestos exposure.

b. Human exposure to asbestos. The proposed rule would provide protection for State and local government employees involved in asbestos-related work in States that do not have OSHA-approved State plans. The activities that would be covered by the proposed rule include the following six categories of work:

• *New construction activities,* which include all projects involving the installation of new asbestos-containing building materials, expected to be predominately asbestos-cement sheet and asbestos-cement pipe.

• *Abatement activities,* which include the removal of asbestos-containing TSI from pipes and boilers and other types of ACM or presumed ACM in buildings.

• *Renovation activities,* which include general building renovation projects. EPA believes that most of these projects will involve the demolition of drywall that has been sealed with asbestos-containing taping materials, and the removal of asbestos-containing roofing felts.

• *Maintenance activities*, which include repair and maintenance of pipes, boilers, furnaces, roofing, drywall, floor and ceiling tiles, lighting, and ventilation, heating, and air conditioning systems.

• *Custodial work*, which includes dusting, sweeping and vacuuming.
 • *Brake and clutch repair work*.
 The following table summarizes the baseline asbestos exposures for workers performing these activities, as well as

the incremental exposure reductions expected to be achieved through this rulemaking. For most activity categories, EPA estimates that worker exposures will decrease by at least one order of magnitude.

EXPOSED POPULATION AND EXPOSURE LEVELS

Activity	Class/category of work	Population exposed in the initial year of the rule (FTEs)	Exposure levels	
			Baseline	Post-rule
New Construction				
A/C pipe installation	NA	8	0.0350	0.0025
A/C sheet installation	NA	100	0.1000	0.0072
Subtotal		108		
Abatement				
Building abatements	I	25	0.1801	0.0104
Boiler/pipe abatements	I	15	0.1801	0.0104
Subtotal		40		
Renovation				
Drywall demolition	II	2,050	0.1130	0.0065
Roofing felt removal	II	89	0.0900	0.0063
Subtotal		2,140		
Maintenance (Class III)				
Repair leaking pipes	III	70	0.1624	0.0014
Repair/maintain furnaces/boilers	III	72	0.1624	0.0094
Repair roofing	III	148	0.0900	0.0063
Repair drywall	III	226	0.1130	0.0002
Repair/replace floor tiles	III	376	0.0240	0.0003
Subtotal		892		
Maintenance (Class IV)				
Repair/replace ceiling tiles	IV	4	0.0714	0.0018
Repair/adjust ventilation/lighting	IV	68	0.0319	0.0008
Repair heating/air conditioning	IV	62	0.0319	0.0008
Other work above drop ceilings	IV	19	0.0492	0.0013
Subtotal		153		
Custodial work	IV	51,752	0.0459	0.0004
Brake and clutch repair				
Low pressure/wet cleaning method ..	GI	2,032	0.0041	0.0041
Aerosol spray method	GI	1,451	0.0141	0.0041
Wet methods	GI	2,322	0.0122	0.0041
Subtotal		5,805		
Building occupants	NA	4,007,710	0.00008	0.00004
School children	NA	20,781,696	0.00008	0.00004
Totals				
All activities		24,850,296		
All activities, excluding school children.		4,068,600		
All activities, excluding school children and building occupants.		60,890		

See Table 3-3 of the Economic Analysis (Ref. 18).

EPA finds that reducing asbestos worker exposures will also result in reduced exposures for incidentally exposed populations, i.e., individuals who are exposed to asbestos without actually performing work on ACM. These populations are:

• *School children*. The proposed rule covers State and local government employees performing asbestos-related work in States without OSHA-approved State plans. A number of the activities that would be covered by the proposed rule occur in public schools. Thus, one incidentally exposed population that would benefit from the proposed rule would be individuals exposed to

asbestos as children while attending public schools in the covered States. EPA expects that these individuals primarily face risks from lung cancer and mesothelioma as adults based on their exposure as children.

• *Building occupants, workers' families, and other individuals who enter buildings covered by the proposed rule*. OSHA has determined that building occupants where asbestos work takes place (e.g., office workers), construction workers performing non-asbestos related work, individuals entering buildings where asbestos work is taking place (e.g., building visitors), and workers' families are at risk of harmful asbestos exposure. NIOSH has

determined that workers' families may be at particular risk of developing asbestosis or mesothelioma from the contaminated clothes of asbestos workers in the family. The proposed rule takes steps to reduce asbestos exposure among family members through the use of decontamination units (29 CFR 1926.1101(j)) and the use of protective clothing that remains at the workplace or is disposed of (29 CFR 1926.1101(i)). Except for building occupants, custodial workers and school children, no quantitative estimates are available regarding the number of people that are incidentally exposed or their exposure level. The provisions of the proposed rule would decrease the

potential of harmful exposure for these individuals and consequently decrease the expected incidence of asbestos-related death and disease among family members.

The preceding table also presents the estimated exposure reductions attributable to this rule for school children and other building occupants. EPA believes that the controls that would be imposed by this proposal would reduce the incidental asbestos exposures for these populations by 50%.

c. *Environmental effects of asbestos.* This proposed rule is directed at risks posed by asbestos in the workplace, not in the ambient environment. EPA therefore did not consider the environmental effects of asbestos in proposing this rule.

d. *The benefits of asbestos for various uses and the availability of substitutes for those uses.* This proposed rule would protect workers exposed to asbestos during construction work and during automotive brake and clutch repair work. Some of this work could involve removal of asbestos. This proposed rule would not, however, require any person to remove asbestos from an existing installation. The person responsible for managing existing installations of asbestos must make the decision whether the benefits of retaining or managing that installation exceed the benefits of removing the asbestos and replacing it with another material. As part of that decision, that person will evaluate the cost and availability of substitutes for asbestos. If the person concludes that satisfactory substitutes are not available at an acceptable price, the person is free to decide that the benefits of maintaining the installation exceed the costs of removing it, and on that basis may leave the asbestos in place. EPA therefore did not consider the benefits of asbestos for various uses and the availability of substitutes for those uses in proposing this rule.

e. *Economic consequences of this proposed rule.* This proposed rule would reduce workers' and building occupants' exposure to asbestos, and would thereby reduce the incidence of cancer and other injurious health effects among these populations. The Economic Analysis for this proposed rule (Ref. 18) provides a detailed analysis of the economic benefits associated with the reduced incidence of these diseases. This proposal would also impose new requirements on State and local governments that would require these entities to incur compliance costs. The Economic Analysis also analyzes in detail the incremental costs to State and local governments of complying with

the proposed rule. In evaluating these incremental costs, EPA assumes that affected State and local governments are in compliance with requirements of the current WPR, the asbestos National Emission Standard for Hazardous Air Pollutants (40 CFR part 61, subpart M), and the Asbestos-in-Schools Rule (40 CFR part 763, subpart E). These incremental benefits and compliance costs are summarized in this unit.

i. *Economic benefits.* EPA has assessed the economic benefits of the proposed rule and has provided quantitative estimates for some of these benefits.

- *Avoided cases of lung cancer and mesothelioma.* Sixty-five years of exposure reduction under the proposed rule would reduce the number of lung cancer and mesothelioma cases among exposed workers and building occupants by 71.58 cases. A majority of these avoided cases occur among custodial workers, where 58.14 cases (81.2% of the number of cases among exposed workers and building occupants) are avoided. The next largest number of avoided cases, 3.96, occurs among building occupants. The proposed rule would also affect some activities in public schools in States without OSHA-approved State plans. This would result in a reduction in the risk to school children in these States. EPA estimates that 65.3 million students over a 65-year period would benefit from reduced exposure under the proposed rule. EPA estimates that 65 years of exposure reduction under the proposed rule would result in 65.65 avoided cancer cases among individuals exposed as school children.

The Economic Analysis supporting this proposed rule uses a "value of statistical life" (VSL) technique to associate a dollar value with these avoided cancer cases. There are several types of economic studies that have attempted to determine the VSL. Of these, most use labor market data to determine workers' trade-offs between wages and risk. In addition, some researchers have used contingent valuation to evaluate willingness to pay to avoid risk. One researcher reviewed a large number of studies, with a range of \$2 million to \$11 million per statistical life, and recommended use of the entire range. The most recent review of the results of research using these approaches found a range of values from \$700,000 to \$16.2 million. EPA's Office of Indoor Air selected 26 studies and calculated their mean estimated value of life to be \$5.5 million (1994 dollars), with a standard deviation of \$3.6 million. The Economic Analysis accompanying this proposed rule uses

the Office of Indoor Air estimate, updated to \$6.53 million in anticipated 2001 dollars. The Economic Analysis uses the VSL estimate to value avoided risk at the point of exposure reduction, and discounts the value of avoided risk occurring in years beyond 2001 back to 2001, using a discount rate of 3%.

Based on a VSL analysis, this proposed rule would result in \$405.45 million in monetized benefits attributable to 137.23 avoided cases of lung cancer and mesothelioma. EPA estimates that the 65-year present monetary value of reducing cancer incidence among exposed workers and building occupants under the proposed rule is \$248.09 million. Avoided cancer cases among custodial workers represent the largest share of the total, with a 65-year present monetary value of \$202.34 million (81.6% of the total). In addition, EPA estimates the present monetary value of the avoided cancer risk among individuals exposed as school children to be \$157.36 million.

- *Avoided cases of asbestosis.* EPA estimates that approximately five cases of asbestosis would be avoided under the proposed rule. EPA does not include this estimate among the quantified benefits of the proposed rule, however, because of the uncertainties about applying the available models to activities involving the relatively low doses to which construction, custodial, and brake and clutch repair workers are exposed. In addition, EPA has determined that many individuals who develop asbestosis also develop lung cancer, so presenting estimates of the number of avoided asbestosis cases in conjunction with estimates of the number of avoided lung cancer cases may result in double-counting (i.e., some of the asbestosis cases may also be cases of lung cancer). EPA considers this estimate of avoided asbestosis cases to be only an indication of the potential magnitude of the number of avoided asbestosis cases.

- *Avoided productivity losses associated with non-fatal diseases.* In addition to lung cancer and mesothelioma, asbestos exposure is associated with numerous other diseases such as pleural plaques and pleural effusion. These conditions are caused by the inhalation of asbestos fibers that eventually become lodged in the lungs and airways of exposed individuals. Reducing asbestos exposure levels, along with the use of protective equipment such as respirators, would reduce the amount of asbestos fibers inhaled by exposed individuals, reducing the risk of developing these conditions. However, EPA was not able to quantify the reduction in these cases.

Although these conditions are not fatal, workers who develop them may need to reduce their work time or retire early, resulting in lost productivity. Lost productivity during the period of illness represents a cost associated with the disease. Exposure models that predict the number of these diseases and conditions are not available, making it impossible to quantify the number of cases and the resulting loss in productivity. Nonetheless, a reduction in asbestos exposure would decrease the incidence of non-fatal asbestos-related disease and thus productivity losses associated with these conditions. The reduced incidence of non-fatal diseases would in turn reduce the number of workers who are out of work due to illness. Thus the proposed rule would reduce the amount of lost productivity due to illness, but by an unknown amount.

- *Avoided medical costs associated with non-fatal diseases.* Medical costs are also incurred by individuals who experience non-fatal asbestos-related diseases (pleural plaques and pleural effusion). Estimates of the costs of treating these illnesses, as well as models that predict their incidence, are not available. A reduction in asbestos exposure will reduce the incidence of asbestos-related disease and consequently the medical costs associated with treating those diseases. Reduced exposures should also decrease the severity of cases of illness not

prevented by the proposed rule. Less severe cases will require less medical care and lower medical care costs. Thus this proposal would also reduce medical costs of non-fatal asbestos-related diseases, but by an unknown amount.

- *Decreased risk for exposed individuals not working with asbestos, including workers' families.* Occupants of buildings where asbestos work takes place (e.g., office workers), construction workers performing non-asbestos related work, individuals entering buildings where asbestos work is taking place (e.g., building visitors), and workers' families may be incidentally exposed to asbestos. NIOSH has determined that workers' families may be at particular risk of developing asbestosis or mesothelioma from the contaminated clothes of asbestos workers in the family. The proposed rule takes steps to reduce asbestos exposure among family members through the use of decontamination units and the use of protective clothing that remains at the workplace or is disposed of.

Except for building occupants, custodial workers and school children, no quantitative estimates are available regarding the number of people that are incidentally exposed or their exposure level. The provisions of the proposed rule would decrease the potential of harmful exposure for these individuals and consequently decrease the expected incidence of asbestos-related death and disease among family members.

- ii. *Compliance costs.* EPA estimates that the proposed rule would impose first-year compliance costs of \$63.34 million. Annually thereafter, the real compliance costs are assumed to decline due to attrition of buildings from the stock of those that contain asbestos (i.e., due to abatements or demolitions). Over the 65-year time frame of exposure reduction, the present value of compliance costs is estimated to be \$1.12 billion. The following table provides a summary of the estimated compliance costs (both first-year costs and the 65-year present value of costs) by paragraph of the OSHA Standard, and by the individual requirements for those paragraphs. In the construction sector, the "Methods of compliance" paragraph of the OSHA Construction Standard (29 CFR 1926.1101(g)) accounts for the greatest share of compliance costs. This paragraph results in estimated costs of \$35.84 million in the first year and \$636.16 million over the 65-year period, which represent 56.6% of the total costs of the proposed rule. Within this paragraph, the wet methods requirement accounts for the greatest share of compliance costs. The estimated costs of the wet methods requirement are \$21.65 million in the first year and \$384.35 million over the 65-year period, representing 34.2% of the total costs of the proposed rule.

SUMMARY OF COMPLIANCE COSTS BY PARAGRAPH AND REQUIREMENT

Requirement	First-year compliance Cost (\$millions)	65-year present value of compliance costs (\$millions)	Percent of total costs
CONSTRUCTION ACTIVITIES:			
29 CFR 1926.1101(d)—Multi-employer worksites			
Second employer inspections	\$0.39	\$6.91	0.61%
Paragraph subtotal	\$0.39	\$6.91	0.61%
29 CFR 1926.1101(e)—Regulated areas			
Signs and tape	\$3.10	\$55.02	4.89%
Paragraph subtotal	\$3.10	\$55.02	4.89%
29 CFR 1926.1101(f)—Exposure assessment and monitoring			
Initial exposure assessment	\$0.61	\$10.75	0.96%
Paragraph subtotal	\$0.61	\$10.75	0.96%
29 CFR 1926.1101(g)—Methods of compliance			
HEPA vacuums	\$10.31	\$183.09	16.28%
Wet methods	\$21.65	\$384.35	34.18%
Leak-tight containers	\$0.37	\$6.61	0.59%
Local exhaust ventilation	\$0.60	\$10.58	0.94%
Impermeable drop cloths	\$1.80	\$31.96	2.84%
Critical barriers	\$0.06	\$1.00	0.09%
Plastic around HVAC systems	\$0.01	\$0.25	0.02%
Negative pressure enclosures	\$0.00	\$0.00	0.00%
Glove bag systems	\$1.03	\$18.32	1.63%
Paragraph subtotal	\$35.84	\$636.16	56.58%
29 CFR 1926.1101(h)—Respiratory protection			
Respirators	\$3.63	\$64.42	5.73%
Develop respirator programs	\$0.76	\$13.52	1.20%
Fit testing for respirators	\$0.03	\$0.53	0.05%
Paragraph subtotal	\$4.42	\$78.46	6.98%
29 CFR 1926.1101(i)—Protective clothing			

SUMMARY OF COMPLIANCE COSTS BY PARAGRAPH AND REQUIREMENT—Continued

Requirement	First-year compliance Cost (\$millions)	65-year present value of compliance costs (\$millions)	Percent of total costs
Provide clothing	\$0.00	\$0.00	0.00%
Inspect clothing	\$0.05	\$0.80	0.07%
Paragraph subtotal	\$0.05	\$0.80	0.07%
29 CFR 1926.1101(j)—Hygiene facilities and practices			
Paragraph subtotal	\$0.00	\$0.00	0.00%
29 CFR 1926.1101(k)—Communication of hazards			
Notify employees	\$1.46	\$25.99	2.31%
Notify other employees/employers	\$1.47	\$26.01	2.31%
Training	\$2.97	\$52.71	4.69%
Paragraph subtotal	\$5.90	\$104.71	9.31%
29 CFR 1926.1101(l)—Housekeeping			
Paragraph subtotal	\$0.00	\$0.00	0.00%
29 CFR 1926.1101(m)—Medical surveillance			
Medical exams	\$0.75	\$13.27	1.18%
Paragraph subtotal	\$0.75	\$13.27	1.18%
29 CFR 1926.1101(n)—Recordkeeping			
EPA access to records	\$2.37	\$42.14	3.75%
Employee access to records	\$0.26	\$4.67	0.41%
Paragraph subtotal	\$2.64	\$46.81	4.16%
29 CFR 1926.1101(o)—Competent person			
Training	\$5.96	\$105.76	9.41%
Inspection by competent person	\$0.01	\$0.22	0.02%
Paragraph subtotal	\$5.97	\$105.98	9.42%
TOTAL FOR CONSTRUCTION	\$59.65	\$1,015.68	94.17%
GENERAL INDUSTRY BRAKE AND CLUTCH REPAIR:			
29 CFR 1910.1001(d)—Exposure monitoring			
Establish exemption	\$0.40	\$7.16	0.64%
Paragraph subtotal	\$0.40	\$7.16	0.64%
29 CFR 1910.1001(f)—Work practices and controls			
Adopt low pressure/wet cleaning method	\$1.24	\$21.99	1.96%
Paragraph subtotal	\$1.24	\$21.99	1.96%
29 CFR 1910.1001(j)—Hazard communication			
Notify employees	\$1.72	\$30.54	2.72%
Paragraph subtotal	\$1.72	\$30.54	2.72%
29 CFR 1910.1001(k)—Housekeeping			
Leak-tight containers	\$0.32	\$5.65	0.50%
Paragraph subtotal	\$0.32	\$5.65	0.50%
29 CFR 1910.1001(m)—Recordkeeping			
EPA access to records	\$0.01	\$0.18	0.02%
Employees access to records	\$0.001	\$0.022	0.00
Paragraph subtotal	\$0.01	\$0.20	0.02%
TOTAL FOR GENERAL INDUSTRY	\$3.69	\$108.74	5.83%
GRAND TOTALS	\$63.34	\$1,124.42	100.00%

See Table 4–11 of the Economic Analysis (Ref. 18).

In the brake and clutch repair sector, compliance costs are highest for the “Communication of hazards to employees” paragraph of the OSHA General Industry Standard (29 CFR 1910.1001(j)), which includes one requirement applicable to brake and clutch repair work, namely to notify employees. This paragraph results in estimated compliance costs of \$1.72 million in the first year and \$30.54 million over the 65-year time period. This represents 2.72% of the total costs of the proposed rule. The “Methods of compliance” paragraph of the OSHA General Industry Standard (29 CFR 1910.1001(f)) contains one requirement applicable to brake and clutch work, namely to adopt the low pressure/wet cleaning method. This requirement

accounts for \$1.24 million in first year compliance costs and \$21.99 million over the 65-year period, representing 1.96% of the total costs of the proposed rule.

iii. *Other effects.* TSCA section 6(c)(1)(D) also requires EPA, when considering the economic consequences of the rule, to take into account effects on the national economy, small business, technological innovation, the environment, and public health. The effects of this rule on the national economy are addressed in the Economic Analysis (Ref. 18) and Unit IV. As this rule affects only State and local government employers, there are no anticipated impacts on small businesses. The impacts on small government entities are evaluated in the Economic Analysis (Ref. 18) and Unit IV. With respect to technological

innovation, EPA does not believe that this rule will be unduly restrictive, since the underlying OSHA Construction and General Industry Standards allow sufficient flexibility for the development of new technology for asbestos-related work. In addition, this rule’s impacts on technology issues in general and the use of technical standards are discussed in Unit IV. As described in Unit II.B.1.c., EPA did not consider environmental effects in this rulemaking as it is directed towards asbestos exposures in the workplace. Finally, the public health effects of this rule are discussed in Units II.B.1.a. and b.

f. *Social and other qualitative effects.* TSCA section 2 requires EPA, when taking any action under TSCA, to consider the social as well as environmental and economic impacts of

the action. EPA considers social and other non-economic beneficial impacts when determining whether a particular level of risk is "unreasonable" and requires mitigation under TSCA section 6. In evaluating the reasonableness of the risk posed by occupational asbestos exposures to State and local government workers, EPA considered the following social and other qualitative effects of the proposed rule.

- *Equity.* One important social consequence of the proposal would be the elimination of inequitable legal protections for classes of persons based solely upon the identity and location of their employers. Currently, private sector building maintenance and custodial workers enjoy comprehensive protection from excessive asbestos exposures under the OSHA Construction Standard. State and local government building maintenance and custodial workers in the 23 States with OSHA-approved State Plans already enjoy this same level of protection, since the protection afforded by such plans must be as effective as that provided to workers in the private sector. However, asbestos workers engaged in the same activities in the remaining 27 States are currently unprotected. There is an obvious inequity in offering different levels of protection to employees who are performing the same tasks, or even working side-by-side in a common job space. These inequitable conditions are unreasonable, and the fact that 23 States have already provided equivalent protections for their State and local government employees is evidence of the strong general societal interest in providing State and local government workers with a level of protection similar to that enjoyed by their counterparts in the private sector.

- *Reduced implementation burdens.* Having a uniform set of standards for construction and brake and clutch repair employees would have the added social benefit of easing implementation burdens. The OSHA standards are highly detailed and complex, but many excellent training, guidance, and reference resources are available. See <http://www.osha-slc.gov/SLTC/asbestos/>. Yet, because of the lack of consistency between the WPR and the OSHA standards, State and local government workers and their employers in 27 States cannot take advantage of these resources. The burden on the regulated community of essentially re-creating these resources to reflect the minor differences between the WPR and the OSHA standards exists only because of the difficulty in amending the WPR to keep pace with

changes in the OSHA standards. Adoption of the proposal would also avoid potential confusion and mistakes by allowing all workers and their supervisors to learn a single standard and know the requirements that apply to their work without additional training if such workers or supervisors move from the public sector to the private sector or vice-versa.

- *Environmental justice.* Many of the employees who would benefit from the protections of this proposed rule are members of minority and low-income populations. In testimony before OSHA in 1991, the Service Employees International Union (SEIU) described building maintenance workers as being among the "least protected members in our society—largely comprised of ethnic minority groups, new immigrants to our country, what economists refer to as the working poor, many forced to work permanent part-time..." (Ref. 20). As discussed in the Economic Analysis, some minorities are disproportionately represented in certain occupations that would be regulated by this proposal. In addition, EPA's analysis has determined that the median weekly income of workers in most of the occupations that would be covered by this rule is below the median income of all workers nationwide. No segment of the population, regardless of race, color, national origin, or income, should, as a result of EPA's policies, programs, or activities, be more affected by adverse health effects, and all people should live and work in clean, healthy, and sustainable environments.

- *Quality of life.* The health effects of asbestos are discussed in detail in Unit II.B.1.a. Two forms of cancer, carcinoma of the lung and malignant mesothelioma, can result from inhaling asbestos fibers. Another asbestos-related disease, asbestosis, is a chronic and progressive lung disease causing extensive fibrosis of the lungs and, in extreme cases, respiratory failure and death. Exposure to asbestos can cause other respiratory diseases, that, while non-fatal, can significantly impair lung function, reduce lung volume, and cause lung stiffness, making breathing difficult and very painful. Pleural effusion impairs lung function by causing an accumulation of fluid in the lung membranes; and pleural plaques cause a stiffening of the lung tissue that particularly affects breathing during exertion. All these diseases cause physical and psychological pain for the diseased person and psychological pain for friends and family. Reducing the incidence of asbestos-related diseases improves the quality of life for both workers and workers' friends and

families by mitigating these negative consequences. The legislative history of TSCA shows that quality of life was an important Congressional concern as the provisions of TSCA were debated and enacted.

- *Children's health.* EPA's analysis indicates that the proposed rule would significantly reduce the incidence of cancer among individuals with childhood asbestos exposures from school buildings. EPA estimates that 65.65 such cases would be avoided under this rule as a result of exposure reductions over a period of 65 years. Children are more vulnerable than adults to the risks of asbestos for a number of physiological reasons. Children have less well-developed defense mechanisms, they breathe more rapidly, and their metabolic rates are different. The smaller respiratory systems of children may be less likely to clear particles than adult respiratory systems. EPA places a high priority on identifying and assessing environmental health risks and safety risks that may disproportionately affect children. By reducing ambient asbestos concentrations in school buildings, this rule would help protect children from the disproportionate asbestos exposure risk they face.

- g. *Finding of unreasonable risk.* Therefore, having considered the factors discussed in Unit II.B.1., including the serious and irreversible health effects of exposure to asbestos; the present exposure levels among State and local government employees; the economic benefits of the proposed rule, including avoided cases of lung cancer and mesothelioma; the costs to State and local governments of complying with the proposed rule; and the beneficial social and other qualitative consequences of the proposal, especially that of equity; EPA finds under TSCA section 6 that the current exposure to asbestos among unprotected State and local government employees during use or disposal in construction work, custodial work, and brake and clutch repair work presents an unreasonable risk of injury to human health, and that rulemaking is necessary to provide adequate protection against that risk.

- 2. *Selection of least burdensome requirements.* Under TSCA section 6(a), once EPA has determined that a chemical substance or mixture presents an unreasonable risk to health or the environment, EPA must use the least burdensome requirements to protect against that risk. This standard requires EPA to consider the alternative regulatory options presented in TSCA section 6(a), and to choose the least burdensome option. The options set out

in TSCA section 6(a), and EPA's analysis of those options, follows.

a. *A requirement prohibiting or limiting the manufacture, processing, or distribution in commerce of asbestos (TSCA section 6(a)(1)).* EPA did not select this option because such a requirement would only protect workers from the risks of future uses of asbestos. This proposal would protect workers from the risks posed by both future asbestos uses and existing installations of asbestos, which have already been manufactured, processed, or distributed in commerce and are now in use. Moreover, prohibiting or limiting the manufacture, processing, or distribution in commerce of particular uses of asbestos would be an unduly burdensome way to protect State and local government construction, custodial and brake and clutch repair workers from the risks of exposure to asbestos. There may still be appropriate uses for asbestos and products containing asbestos. It is not necessary to burden the economy by prohibiting or limiting the manufacture, processing, or distribution in commerce of asbestos in order to protect a small segment of the population from exposure to asbestos from such products.

b. *A requirement prohibiting or limiting the manufacture, processing, or distribution in commerce of asbestos for a particular use or for a particular use in excess of a specified concentration (TSCA section 6(a)(2)).* As with the option under TSCA section 6(a)(1), EPA did not select this option because such a requirement would only protect workers from the risks of future uses of asbestos. This proposal would protect workers from the risks posed by both future asbestos uses and existing installations of asbestos, which have already been manufactured, processed, or distributed in commerce and are now in use. Moreover, prohibiting or limiting the manufacture, processing, or distribution in commerce of particular uses of asbestos would be an unduly burdensome way to protect a small segment of the population from exposure to asbestos from such uses.

c. *A requirement that asbestos and asbestos-containing material be marked or accompanied by a warning and instructions for its use, distribution in commerce, and/or disposal (TSCA section 6(a)(3)).* This proposal would require, in effect, that employers ensure their employees comprehend warning signs, labels, and instructions posted where asbestos is present, using, if necessary, such techniques as foreign languages, pictographs, graphics, and awareness training. Markings, warnings, or instructions by themselves, however,

would not adequately reduce State and local government workers' exposure to asbestos. These workers' exposure to asbestos during construction work or brake and clutch repair and service work is dependent on the industrial hygiene practices in the workplace, which are largely in the control of the employer. Therefore, this rule would require employers to provide additional protections to reduce their employees' exposure to asbestos.

d. *A requirement controlling manufacture and processing of asbestos and requiring manufacturers and processors to keep records of their manufacturing or processing processes and monitor those processes (TSCA section 6(a)(4)).* EPA did not select this option because such a requirement would only protect workers from the risks of future uses of asbestos. This proposal would protect workers from the risks posed by both future asbestos uses and existing installations of asbestos, which have already been manufactured, processed, or distributed in commerce and are now in use. Moreover, controlling the manufacture or processing of particular uses of asbestos would be an unduly burdensome way to protect a small segment of the population from exposure to asbestos from such uses.

e. *A requirement prohibiting or otherwise regulating any manner or method of commercial use of asbestos (TSCA section 6(a)(5)).* The asbestos present in buildings and in vehicles was sold as commercial products. Therefore, construction work or brake and clutch repair is commercial activity subject to this section. This proposed rule would regulate the manner and method of use of these commercial products by establishing worker protection, training, and hazard communication requirements for State and local government employers whose employees install and maintain these products.

f. *A requirement prohibiting or otherwise regulating any manner or method of disposal of asbestos by anyone who manufactures, processes, uses, or disposes of asbestos for commercial purposes (TSCA section 6(a)(6)).* The removal of asbestos is disposal for commercial purposes subject to this section. Management of asbestos in place is use for commercial purposes. This proposed rule would regulate the manner and method of disposal of these commercial products by establishing worker protection, training, and hazard communication requirements for State and local government employers whose employees remove these products.

g. *A requirement directing manufacturers or processors of asbestos to notify distributors of asbestos, and others in possession of or exposed to asbestos, of unreasonable risks of injury from asbestos, to give public notice of those risks, and to replace or repurchase asbestos (TSCA section 6(a)(7)).* EPA did not select this option for this proposed rule. As with labeling and marking requirements, notifications by themselves would not adequately reduce State and local government workers' exposure to asbestos. These workers' exposure to asbestos during construction work or brake and clutch repair and service work is dependent on the industrial hygiene practices in the workplace, which are largely in the control of the employer. This proposed rule would require employers to use appropriate engineering controls and work practices, and provide their employees with personal protection equipment to reduce their employees' exposure to asbestos. A requirement for the manufacturers to replace or repurchase asbestos-containing building products would also not protect the State and local government workers who must remove installed building products.

h. *Conclusion.* Therefore, having considered the regulatory options in TSCA section 6(a)(1) through 6(a)(7), EPA finds that the least burdensome option for protecting State and local government employees is a regulation based on TSCA sections 6(a)(3), 6(a)(5), and 6(a)(6). This determination is specific to this rulemaking, and EPA may, if warranted, take additional actions to address asbestos risks in the future. If any commenter believes that there is a feasible, less burdensome alternative to the action proposed here that would sufficiently mitigate the unreasonable risk that is the subject of this rulemaking and outweigh the Agency's strong interest in consistency and equity, the commenter should identify this option in the comments and explain how it would sufficiently mitigate the unreasonable risk in a less burdensome manner than the option proposed by the Agency.

3. *Consideration of other Federal laws.* TSCA sections 6(c) and 9 require EPA to consider whether other Federal statutes and regulations are available to address a risk that would otherwise merit regulatory action under TSCA section 6(a). EPA's consideration of other relevant Federal authorities follows.

a. *Actions under other Federal laws administered by EPA.* Under TSCA section 6(c), EPA may not promulgate a rule under TSCA section 6(a) if EPA

determines that a risk of injury to health or the environment could be eliminated or reduced to a sufficient extent by actions taken under another statute administered by EPA, unless EPA finds it is in the public interest to protect against the risk by action under TSCA. (See also TSCA section 9(b).) EPA has analyzed other statutes administered by EPA and concludes that none provide sufficient authority to eliminate or reduce the risks to State and local government workers from asbestos.

- *Clean Air Act (CAA)*. On April 6, 1973, EPA used the authority of the CAA to list asbestos as a hazardous air pollutant, establish a "no visible emissions" standard for manufacturers, and ban the use of spray-applied asbestos-containing material as insulation in buildings (Ref. 21). EPA amended this regulation on October 12, 1975, to ban asbestos-containing pipe lagging (Ref. 22), and on June 19, 1978, extended the ban to all uses of sprayed-on asbestos (Ref. 23). Under the CAA, EPA also regulates operations involving the demolition or renovation of buildings containing friable asbestos and the disposal of wastes generated by such operations. However, the CAA does not apply directly to the protection of workers exposed to indoor air. Consequently any possible additional use of that statute could leave many workers inadequately protected from asbestos in indoor air.

- *Resource Conservation and Recovery Act (RCRA)*. Under RCRA, 42 U.S.C. 6901–6992k, EPA could list asbestos as a hazardous waste and subject asbestos waste to general requirements designed to protect human health. However, RCRA jurisdiction is limited to those materials that the Agency has determined are wastes. Many of the activities covered by this rule do not involve handling of asbestos as waste. For example, this proposed rule would adopt by cross-reference standards for repair, maintenance and installation of asbestos-containing materials referenced at 29 CFR 1926.1101(a)(3) and (4). While RCRA authority could extend to reduction of worker exposure to the extent activities covered by this proposed rule involve waste handling, it could not cover all the risks these activities pose to workers. Thus, RCRA regulations could not reduce risks to a sufficient extent.

- *Actions under Federal laws not administered by EPA*. Under TSCA section 9(a), EPA is required to review other Federal authorities not administered by EPA to determine whether action under those authorities may prevent or reduce a given risk. The only statute not administered by EPA

that addresses risks from workplace exposure to asbestos is the OSH Act. However, the OSH Act does not apply to State and local government employees. The OSH Act does provide that a State can adopt an asbestos standard as part of its own State worker protection plan, subject to approval by the Secretary of Labor. Twenty-three States have implemented State plans. Twenty-seven States do not have OSHA-approved State plans. EPA has therefore determined that there is no statute administered by another Federal agency that can prevent or reduce the risk of asbestos exposure presented to State and local government employees not covered by OSHA-approved State plans during asbestos-related construction and brake and clutch repair work. EPA's analysis of this issue is discussed in the **Federal Register** of April 25, 1986 (Ref. 2).

- *c. Consultation and coordination with other Federal agencies*. TSCA section 9(d) directs that in implementing TSCA, EPA consult and coordinate with other Federal agencies for the purpose of achieving the maximum enforcement of TSCA while imposing the least burdens of duplicative requirements on those who must comply with those requirements. As a result of the close working relationship with OSHA, EPA finds that the most effective way of eliminating duplication and overlap and ensuring consistency between the WPR and the OSHA Asbestos Standards is by cross-referencing the OSHA Asbestos Standards set out at 29 CFR 1910.1001 and 29 CFR 1926.1101.

The goals both of Congress and of the Administration would be advanced by ensuring that the WPR and the OSHA Asbestos Standards offer consistent protections and offer them at the same time to both public and private sector workers. The legislative history of TSCA reflects Congress' concern that some of the greatest risks from exposure to toxic chemicals occur in the workplace. Congress clearly intended that TSCA be available to address those risks, but, at the same time, acknowledged OSHA's expertise in establishing workplace standards. TSCA section 9(d) reflects Congress' desire that EPA and OSHA work together in identifying and protecting against risks to workers from toxic chemicals. Therefore, EPA has, since 1985, exercised its authority under TSCA section 6 to fill the gap in coverage in the OSH Act by protecting State and local government employees from the risks of asbestos, and has done so in a way that imposes the least burden of duplicative requirements by maintaining consistency where possible

between the WPR and the OSHA Asbestos Standards.

While it has always been EPA policy to maintain consistency between the WPR and the OSHA Asbestos Standards, prior to this proposal EPA has implemented this policy by reprinting those requirements in full at 40 CFR part 763, subpart G. However, OSHA has frequently revised its standard (the CFR lists thirteen rules revising the Asbestos Standard since 1986). EPA must wait until the OSHA revisions are finalized before initiating conforming changes to the WPR. By the time EPA's conforming changes take effect, OSHA has issued new revisions to the Asbestos Standard. The result is that the WPR has, in fact, rarely been completely consistent with the OSHA Standards, and, as more protective and less burdensome standards have gone into effect for the private sector, protections for State and local government employees have lagged behind. If the WPR cross-referenced the OSHA Asbestos Standards instead of reprinting them in full, revisions to the OSHA standard would take effect at the same time in the WPR, and public and private sector employees would be protected equally against the risks of asbestos.

- *d. Conclusion*. Therefore, having considered whether other Federal statutes and regulations are available to address the risks from exposure to asbestos among State and local government employees during use or disposal in construction work and in brake and clutch repair work, EPA concludes that rulemaking under TSCA section 6 is necessary to provide adequate protection against that risk to State and local government employees who are not otherwise covered under an OSHA-approved State plan that is as effective as the OSHA regulations, or a State asbestos worker protection plan exempted from the requirements of the WPR by EPA under 40 CFR 763.123.

- *4. Analysis of regulatory alternatives*. EPA considered and analyzed four regulatory alternatives or options in developing this proposed rule:

- *Option A*. Both the PEL and the scope of the proposed rule remain unchanged (i.e., no action).
- *Option B*. The PEL is lowered from 0.2 f/cc to 0.1 f/cc, but the scope of the proposed rule remains the same.
- *Option C*. The PEL remains the same, but the scope of the proposed rule is expanded to include new construction, maintenance, renovation, custodial, and brake and clutch repair activities.
- *The proposed rule*. The PEL is lowered from 0.2 f/cc to 0.1 f/cc, and the

scope of the proposed rule is expanded to include new construction,

maintenance, renovation, custodial, and brake and clutch repair activities.

SUMMARY OF REGULATORY OPTIONS

Option	PEL	Scope
A (no action)	0.2 f/cc	Abatement activities only
B	0.1 f/cc	Abatement activities only
C	0.2 f/cc	New construction, abatement, maintenance, renovation, custodial, and brake and clutch repair activities
Proposed rule	0.1 f/cc	New construction, abatement, maintenance, renovation, custodial, and brake and clutch repair activities

See Table 5–1 of the Economic Analysis (Ref. 18). For each of the four options, the State-level coverage would remain the same: The rule (or option) would continue to cover State and local government employees in States without OSHA-approved State plans.

a. *Quantified costs and benefits.* EPA estimated the costs and benefits for Options A, B, C, and the proposed rule. In estimating the benefits for each option, EPA estimated the number of avoided cancer cases among exposed workers, building occupants, and school children, associated with 65 years of reduced asbestos exposure. EPA also placed a monetary value on the avoided risk associated with the 65 years of reduced exposure and then calculated the present monetary value of the avoided cancer risk. EPA estimated compliance costs by calculating the first-year compliance cost of each option. This estimate was extrapolated over 65 years of exposure reduction, assuming building attrition would cause the costs of abatement, renovation, maintenance, and custodial activities to decline over time, while administrative, new construction, and brake and clutch repair activity costs would not be affected by building attrition.

• *Option A—PEL unchanged, scope unchanged (baseline).* Under Option A, the current version of the WPR (40 CFR part 763, subpart G) would remain in effect. The PEL would remain unchanged at 0.2 f/cc and the proposed rule would apply only to abatement activities. This option would result in no incremental costs or benefits.

• *Option B—reduced PEL, scope unchanged.* Under Option B, the PEL would be reduced from 0.2 f/cc to 0.1 f/cc, but the scope of the proposed rule would remain unchanged. Thus, compared to the current rule, Option B would reduce exposure to asbestos among abatement workers and incidentally exposed populations in affected buildings, but would not apply to additional activities. EPA estimates

that, over 65 years, Option B would reduce asbestos exposure to a total of 201,275 people, of whom 65 would be exposed workers and the remainder would be building occupants and school children. EPA estimates that this exposure reduction would, over 65 years, prevent 0.36 cases of asbestos-related cancer among this total population, which translates into an estimated present value of \$1.07 million. Excluding building occupants and school children, Option B results in 0.17 avoided cancer cases associated with 65 years of exposure reduction, which has an estimated present value of \$0.59 million. The estimated 65-year present value of compliance costs for Option B is \$24.00 million.

• *Option C—PEL unchanged, expanded scope.* Option C would leave the PEL unchanged from the current WPR at 0.2 f/cc, but would expand the scope of the WPR to include new construction, maintenance, renovation, custodial, and brake and clutch repair activities, in addition to the abatement activities covered by the current WPR. Compared to the current rule, Option C would provide an expanded scope of coverage, but would not increase the level of protection (i.e., the PEL would remain 0.2 f/cc). EPA estimates that, over 65 years, Option C would reduce asbestos exposure for a total population of 71.9 million individuals, 102,700 of whom would be directly exposed workers and the remainder of whom would be incidentally exposed building occupants and school children. EPA estimates that 65 years of exposure reduction would lead to 26.85 avoided cases of asbestos-related cancer among this total population, with an estimated present value of \$83.46 million. Among exposed workers, the reduction in cancer incidence is estimated to be 17.2 cases associated with 65 years of exposure reduction, which has an estimated present value of \$59.48 million. The estimated 65-year present

value of total compliance costs for Option C is \$939.53 million.

• *The proposed rule—reduced PEL, expanded scope.* The proposed rule would lower the PEL from 0.2 f/cc to 0.1 f/cc and expand the scope of the asbestos WPR to include new construction, maintenance, renovation, custodial, and brake and clutch repair activities in addition to the abatement activities covered by the current WPR. The proposed rule would provide protection to a total population of 71.9 million over 65 years of exposure reduction, 102,765 of whom are exposed workers. Furthermore, the proposed rule would reduce the number of asbestos-related cancers associated with 65 years of exposure by 137.23 cases, valued at an estimated present value of \$405.45 million. Excluding building occupants and school children (i.e., focusing on just exposed workers), the proposed rule results in 67.63 avoided cancer cases associated with 65 years of exposure reduction, with an estimated present value of \$234.32 million. The estimated 65-year present value of compliance costs is \$1,124.42 million.

b. *Comparison of quantified costs and benefits.* For each option and the proposed rule, EPA estimated the costs, benefits, and net benefits for all populations (exposed workers, building occupants, and school children) and for exposed workers only. The cost, benefit, and net benefit estimates for exposed workers are singled out because the rule is directed at reducing the exposure of this population and because building occupants and school children are only incidentally exposed. EPA compared the four options using six quantitative criteria.

• *Protectiveness.* The proposed rule and Option B would set the PEL at 0.1 f/cc, while Options A and C would set the PEL at 0.2 f/cc. Thus, the proposed rule and Option B are both more protective than Options A and C.

• *Scope.* The proposed rule and Option C would both provide

incremental protection to significantly larger populations than Options A and B. Both the proposed rule and Option C would provide incremental protection to a population of 71.9 million, of which slightly less than 103,000 are exposed workers. Option B would provide additional protection to a population of only 201,275 (0.28% of the population protected by the proposed rule), of which 65 are exposed workers (0.06% of the exposed workers protected by the proposed rule). Option A, which would not change the current asbestos WPR, would not provide additional protection to any populations.

• *Estimated benefits.* The proposed rule would result in significantly more avoided cancer cases and, consequently, a significantly larger level of monetized benefits when compared with the other regulatory options. The proposed rule would reduce the incidence of asbestos-related cancers associated with 65 years of exposure reduction by 137 cases, which would result in a monetary benefit of \$405 million. Among exposed workers, the proposed rule would reduce the incidence of asbestos-related cancer associated with 65 years of exposure reduction by 68 cases, valued at \$234 million. Option C would reduce the asbestos-related cancer incidence by only 27 cases (19.6% of the proposed rule's total), valued at \$83 million

(20.6% of the proposed rule's total). Among exposed workers, Option C would reduce the incidence of asbestos-related cancer by 17 cases (25.4% of the proposed rule's total), valued at \$59 million (25.4% of the proposed rule's total). Option B would result in approximately \$1.0 million in monetized benefits while Option A would result in no incremental avoided cases and thus no incremental monetized benefits.

• *Estimated compliance costs.* Option A is the least costly of the four options, resulting in no (\$0) incremental compliance costs because no incremental action would be required. The proposed rule is the most costly option, resulting in a 65-year present value compliance cost of \$1.1 billion. For Option B, the 65-year present value of compliance costs is \$24.00 million (2.1% of the proposed rule's total), while for Option C, the 65-year present value of compliance costs is \$939.53 million (83.6% of the proposed rule's total).

• *Efficiency.* Option A would result in the largest monetized net benefit (monetized benefits minus monetized costs), which is \$0. Each of the other options would result in negative net benefits, or a net cost. The proposed rule would result in the second largest net cost, with costs exceeding estimated

benefits by \$719 million. The estimated costs for Option C exceed its estimated benefits by \$856 million (19.1% larger than the net cost for the proposed rule), and the estimated costs for Option B exceed its estimated benefits by \$22.93 million (3.2% of the proposed rule's total).

• *Ratio of estimated compliance costs to estimated benefits.* The following table presents the cost-benefit ratio for each option. The cost-benefit ratio, measured as the ratio of compliance costs to monetized benefits, measures the cost that would be incurred for each dollar of benefits. The proposed rule has the lowest (i.e., most preferable) cost benefit ratio for both all exposed populations (2.77) and exposed workers alone (4.80). Option C has a cost-benefit ratio of 11.26 for all exposed populations (4.07 times the cost-benefit ratio for the proposed rule) and 15.80 for exposed workers alone (3.29 times the cost-benefit ratio for the proposed rule). Option B has a cost-benefit ratio of 22.43 for all exposed populations (8.10 times the cost-benefit ratio for the proposed rule) and 40.68 for exposed workers alone (8.48 times the cost-benefit ratio for the proposed rule). Cost-benefit ratios could not be calculated for Option A because costs and monetized benefits are both \$0.

SUMMARY OF ESTIMATED COSTS, BENEFITS, AND NET BENEFITS FOR ALTERNATIVE REGULATORY OPTIONS

Option/section	PEL (f/cc)	Incremental population protected	Estimated benefits		Present value of compliance costs (\$millions)	Estimated net benefit (\$millions)	Cost-benefit ratio
			Avoided cancer cases	Present monetary value (\$millions)			
Proposed Rule—PEL Reduced, expanded scope: All populations Exposed workers	0.1	71,887,159	137.23	\$405.45	\$1,124.42	(\$718.97)	2.77
	0.1	102,765	67.63	\$234.32	\$1,124.42	(\$890.09)	4.80
Option A (baseline)—PEL unchanged, scope unchanged: All populations Exposed workers	0.2	0	0.00	\$0.00	\$0.00	\$0.00
	0.2	0	0.00	\$0.00	\$0.00	\$0.00
Option B—PEL Reduced, scope unchanged: All populations Exposed workers	0.1	201,275	0.36	\$1.07	\$24.00	(\$22.93)	22.43
	0.1	65	0.17	\$0.59	\$24.00	(\$23.41)	40.68
Option C—PEL unchanged, expanded scope: All populations Exposed workers	0.2	71,886,942	26.85	\$83.46	\$939.53	(\$856.07)	11.26
	0.2	102,548	17.20	\$59.48	\$939.53	(\$880.05)	15.80

See Table 5–8 of the Economic Analysis (Ref. 18).

Based on these comparisons, EPA has selected the proposed rule as the

preferred option for the following reasons:

• The proposed rule would be the most protective (i.e., would result in the lowest PEL).

• The proposed rule would provide incremental protection to the largest population.

• The proposed rule would result in the largest benefits.

• The proposed rule would offer the lowest ratio of costs to benefits.

The proposed rule, however, would also be the most costly and would result in the second largest net cost among the four options. Nevertheless, EPA has determined that the increased cost and net cost are justified by the additional benefits and protection offered by the proposed rule. In moving from Option C to the proposed rule, the compliance costs increase by a factor of 1.2 (\$1.1 billion ÷ \$939.53 million), but the number of avoided cancer cases increases by a factor of 5.1 (137.23 cases ÷ 26.85 cases). Likewise, in moving from Option B to the proposed rule, the compliance costs increase by a factor of 46.85 (\$1.1 billion ÷ \$24.00 million), but the number of avoided cancer cases increases by a factor of 381 (137.23 cases ÷ 0.36 cases). EPA does not consider Option A to be a viable option because it does not result in any additional protection.

c. *Comparison of non-quantified benefits.* EPA has identified a number of benefits that could not be quantified (see Unit II.B.1.a.). Included among these benefits are:

- Reductions in the incidence of asbestosis.
- Reductions in the incidence of pleural plaques and pleural effusion.
- Reductions in productivity losses associated with non-cancerous health effects.

• Reductions in medical costs associated with non-cancerous health effects.

• Improved quality of life.

• Decreased risk for individuals who may be incidentally exposed to asbestos, including building visitors and members of workers' families.

As discussed in Unit II.B.1.a., EPA was unable to provide quantitative estimates for the benefit categories listed in this unit. It is possible, however, to compare the four options in terms of their protectiveness and scope, and draw some conclusions with regard to the option that would provide the largest level of benefits for each benefit category. Each of the benefits listed in this unit are positively influenced by the level of protection (i.e., a lower PEL implies more benefits) and by the incremental population covered (i.e., a larger incremental population implies more benefits). Thus, options can be compared and ranked based on these two criteria.

The following table provides EPA's ranking of the proposed rule and the three alternative options in terms of the level of the benefit that each would provide. In the table, a ranking of 1 indicates that EPA expects that option to provide the largest level of benefits among the four options, while a ranking of 4 indicates that EPA expects that

option to provide the least benefits among the four options.

These rankings reveal three distinct trends in comparing the four options. First, the proposed rule is always expected to produce the largest level of benefits. The proposed rule is at least as protective (i.e., in terms of value of the PEL) as each of the other options and provides protection to a larger incremental population than the other three options. Based on these two considerations, the proposed rule should provide a larger level of each non-quantified benefit, compared to the other options. This is consistent with ranking of the quantified benefits, where the proposed rule would result in the largest reduction in asbestos-related cancer. Second, Option A would provide the lowest level of benefits in each non-quantified benefit category. This follows from the fact that Option A involves no changes to the current WPR. Thus, since the proposed rule and both Options B and C provide either additional coverage or a reduced PEL, all three options must provide a larger level of benefit compared to Option A. Finally, it is not possible to determine the relative ranks of Options B and C. On the one hand, Option B offers more protection (in terms of a lower PEL) but on the other hand Option C provides incremental protection to a larger population.

RANKING OF PROPOSED RULE AND OPTIONS A, B, AND C FOR THE NON-QUANTIFIED BENEFITS OF REDUCING ASBESTOS EXPOSURE

Non-quantified benefit	Proposed rule	Option A	Option B	Option C
Reductions in the incidence of asbestosis	1	4	2	2
Reductions in the incidence of pleural plaques and pleural effusion	1	4	2	2
Reductions in productivity losses associated with non-cancerous health effects	1	4	2	2
Reductions in medical costs associated with non-cancerous health effects	1	4	2	2
Improved quality of life	1	4	2	2
Decreased risk for individuals who may be incidentally exposed to asbestos, including workers' families	1	4	2	2

Note: These are subjective rankings based on EPA's best professional judgement only.

See Table 5–9 of the economic Analysis (Ref. 18).

d. *Qualitative measures of costs and benefits.* This proposed rule would establish consistency between the protections offered under the WPR to State and local government employees working with asbestos-containing materials and under the OSHA Construction and General Industry Standards to private sector employees working with those materials. Fairness and equity dictate equivalent protection for all persons who work with asbestos-containing materials, whether those persons are employed by the private

sector or by a specific State or local government. Currently, all private sector workers, as well as State and local government employees in the 23 States that have OSHA-approved State plans, are protected by the more stringent OSHA regulations. EPA is proposing to achieve equity for the remaining State and local government workers by amending the WPR to adopt recent amendments to the OSHA Asbestos Standards that provide additional worker protections.

The OSHA Asbestos Standards, as amended in 1994, establish a PEL of 0.1 f/cc for all exposed workers. EPA's

current asbestos WPR covers only abatement workers and sets a PEL of 0.2 f/cc. Thus, the current EPA rule is less protective (i.e., is based on a higher PEL) and covers fewer exposed workers (i.e., only abatement workers) than the OSHA standards. The proposed rule would eliminate these inequities by providing identical protection and coverage to State and local government employees performing asbestos-related work in States without OSHA-approved State plans.

Options A, B, or C would not provide these State and local government employees with the same protection and

coverage as the OSHA Standards provide to private sector workers. Option A would provide less protection (i.e., a higher PEL) and would cover workers in fewer activities compared to those covered by OSHA. Option B would provide the same level of protection (i.e., the same PEL), but would cover workers in fewer activities compared to those covered by OSHA. Option C would cover the same number of activities, but would provide less protection (i.e., a higher PEL).

Therefore, the proposed rule is preferable to the other three options considered because it would provide equity in terms of protectiveness and coverage between workers in the private sector and State and local government employees.

e. *Summary.* Based on its comparison of the four options' estimated quantified costs and benefits, estimated non-quantified benefits, and qualitative measures of costs and benefits, EPA has determined that the proposed rule provides the greatest net benefits compared to the other three options considered, especially in light of the equity considerations discussed in Unit II.B.4.

- *Estimated quantified costs and benefits.* The proposed rule is the most protective (i.e., lowest PEL), provides incremental protection to the largest exposed population, results in the largest benefits, and offers the lowest ratio of costs to benefits. The proposed rule, however, is the most costly and results in the second largest net cost among the four options (though all options with the exception of Option A result in a negative net benefit). Nevertheless, EPA finds that the increased cost is justified by the additional benefits and protection offered by the proposed rule.

- *Estimated non-quantified benefits.* EPA expects that the proposed rule would result in a larger level of benefits for each unquantifiable category of benefits in comparison with each of the other three options. EPA bases this conclusion on the fact that the proposed rule is at least as protective (i.e., in terms of value of the PEL) as each of the other options and provides protection to a larger incremental population than the other three options.

- *Qualitative measures of costs and benefits.* The proposed rule is the only option that would provide coverage comparable to the OSHA Asbestos Standards. The proposed rule would provide public employees in States without approved OSHA State plans with the same level of protection (i.e., the PEL) and would cover the same set of activities as is covered in the OSHA

standards. The other options would provide less protection (Options A and C) or less scope of coverage (Options A and B) compared to OSHA's Asbestos Standards.

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IV. Regulatory Assessment Requirements

A. Regulatory Planning and Review

Under Executive Order 12866, entitled *Regulatory Planning and Review* (58 FR 51735, October 4, 1993), this action is not a "significant regulatory action" subject to review by the Office of Management and Budget (OMB), because this action is not likely to result in a rule that meets any of the criteria for a "significant regulatory action" provided in section 3(f) of the Executive Order.

EPA has prepared an analysis of the potential impact of this action, which is estimated to cost \$63.34 million in the first year of the rule and then decline annually thereafter. The analysis is contained in a document entitled "Economic Analysis of the Asbestos Worker Protection Rule" (Ref. 18). This document is available as a part of the public version of the official record for this action (instructions for accessing this document are contained in Unit I.B.), and is briefly summarized in Unit II.B.

B. Regulatory Flexibility Act

Pursuant to section 605(b) of the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), 5 U.S.C. 601 *et seq.*, EPA hereby certifies that this proposed action, if promulgated as proposed, will not have a significant economic impact on a substantial number of small entities. The factual basis for EPA's determination is presented in the small entity impact analysis prepared as part of the Economic Analysis for this proposed rule (Ref. 18), and is briefly summarized here.

For purposes of analyzing potential impact on small entities, EPA used the definition for small entities in RFA section 601. Under RFA section 601, "small entity" is defined as:

1. A small business that meets Small Business Administration size standards codified at 13 CFR 121.201.

2. A small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000.

3. A small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

Of the three categories of small entities, only small governmental jurisdictions are affected by this proposed rule. As such, EPA's analysis of potential small entity impacts assesses the potential impacts on small governmental jurisdictions.

Based on the definition of "small government jurisdiction," no State-level government covered by the asbestos WPR can be considered small. Therefore, the small government entities potentially impacted by the proposed asbestos WPR are local governments (e.g., county, municipal, or towns) and school districts.

The proposed amendments to the asbestos WPR may impact local governments in the 27 States without approved OSHA State plans by imposing incremental compliance costs for asbestos-related maintenance, renovation, and brake and clutch repair. There are 24,495 small government jurisdictions that are potentially impacted by the asbestos WPR. However, the estimated amounts of the impact are all extremely low. In each of the States, the impact for all small local governments is estimated to be less than 0.1% of revenues available for compliance. EPA estimated that the largest impact would occur for small local governments in Arkansas and Delaware, where the upper bound estimate of compliance costs as a

percent of available revenues is estimated to be 0.051%. For small local governments as a whole, compliance costs associated with the asbestos WPR are estimated to represent 0.024% of available revenues. Therefore, the Agency has concluded that the asbestos WPR will not have a significant impact on small government entities.

Small school districts are defined as school districts serving a resident population of less than 50,000. In the 27 covered States, there are 17,846 small school districts that are potentially impacted by the asbestos WPR. The estimated impact of compliance costs on all small school districts is estimated to be 0.01% of available revenues. The largest impact is estimated for Mississippi where compliance costs as a percent of available revenues are estimated to equal 0.013%. The Agency has therefore concluded that the proposed asbestos WPR will not have a significant effect on the revenues of small school districts.

Although this proposed rule will not have a significant economic impact on a substantial number of small entities, EPA is interested in comments and suggestions for further reducing the potential impact for small entities. In particular, EPA is interested in how any further reductions might be achieved while ensuring that the WPR remains consistent with the OSHA Asbestos Construction and General Industry Standards. EPA requests comment on opportunities for burden reduction and other issues related to impacts on small entities.

Additional details regarding EPA's basis for this certification are presented in the Economic Analysis (Ref. 18), which is included in the public version of the official record for this action. This information will also be provided to the SBA Chief Counsel for Advocacy upon request. Any comments regarding the impacts that this action may impose on small entities should be submitted to the Agency in the manner specified in Unit I.C.

C. Paperwork Reduction Act

Pursuant to the Paperwork Reduction Act (PRA), 44 U.S.C. 3501 *et seq.*, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. The OMB control numbers for EPA's regulations, after appearing in the preamble to the final rule, are listed in 40 CFR part 9, and included on the related collection instrument.

The information collection requirements contained in this proposed rule have been submitted to OMB for

review and approval pursuant to the PRA and OMB implementing regulations at 5 CFR 1320 *et seq.* The burden and costs related to the information collection requirements contained in this proposed rule are described in an Information Collection Request (ICR). This ICR proposes to amend the existing ICR for the current WPR which is approved through September 30, 2001, under OMB No. 2070-0072 (EPA ICR No. 1246.06). A copy of this ICR, which is identified as EPA ICR No. 1246.07, has been included in the public version of the official record described in Unit I.B.2., and is available electronically as described in Unit I.B.1., at <http://www.epa.gov/opperid1/icr.htm>, or by e-mailing a request to farmer.sandy@epa.gov. You may also request a copy by mail from Sandy Farmer, Collection Strategies Division, Environmental Protection Agency (2822), Ariel Rios Bldg., 1200 Pennsylvania Ave., NW., Washington, DC 20460, or by calling (202) 260-2740.

As described in Unit II.A.2., this amendment would require employers to collect, disseminate, and maintain information relating to employee asbestos exposures, respiratory protection, medical surveillance, and training. The records maintained as a result of this information collection will provide EPA with the data necessary for effective enforcement of the WPR, as authorized under TSCA sections 6 and 8.

The public reporting burden for this collection of information is estimated to average, on an annual basis, 21.96 hours per respondent, including the time for reviewing instructions, gathering and maintaining the data needed, and completing and reviewing the collection of information. EPA estimates that 25,312 respondents would incur these burdens, for a total annual respondent burden of 555,870 hours.

As defined by the PRA and 5 CFR 1230.3(b), "burden" means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of

information; and transmit or otherwise disclose the information.

Comments are requested on EPA's need for this information, the accuracy of the provided burden estimates, and any suggested methods for minimizing respondent burden, including through the use of automated collection techniques. Send comments on the ICR to EPA as part of your overall comments on this proposed rule in the manner specified in Unit I.C. Send a copy of your comments on the ICR to OMB as specified by 5 CFR 1320.11(a), by mailing them to the Office of Information and Regulatory Affairs, Office of Management and Budget, 725 17th St., NW., Washington, DC 20503, marked "Attention: Desk Officer for EPA." Include the ICR number in any correspondence. Since OMB is required to make a decision concerning the ICR between 30 and 60 days after April 27, 2000, a comment to OMB is best assured of having its full effect if OMB receives it by May 30, 2000. In developing the final action, EPA will consider any OMB or public comments received regarding the information collection requirements contained in this proposal.

D. Unfunded Mandates Reform Act

Pursuant to Title II of the Unfunded Mandates Reform Act of 1995, (UMRA), Public Law 104-4, EPA has determined that this rule does not contain a Federal mandate that may result in expenditures of \$100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in any 1 year. As discussed in the Economic Analysis accompanying this proposed rule, the rule would result in estimated expenditures of at most \$63.34 million in any 1 year. In addition, EPA has determined that this proposed rule would not significantly or uniquely affect small governments. For small local governments as a whole, compliance costs associated with the WPR represent 0.024% of revenues assumed to be available for compliance. Moreover, the impact of compliance costs on small school districts as a whole would be 0.01% of available revenues. Thus, this proposed rule is not subject to the requirements of UMRA sections 202, 203, 204, and 205.

E. Federalism

Executive Order 13132, entitled *Federalism* (64 FR 43255, August 10, 1999), requires EPA to develop an accountable process to ensure "meaningful and timely input by State and local government officials in the development of regulatory policies that have federalism implications." "Policies that have federalism implications" is

defined in the Executive Order to include regulations that have "substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government."

Under section 6 of Executive Order 13132, EPA may not issue a regulation that has federalism implications, that imposes substantial direct compliance costs, and that is not required by statute, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by State and local governments, or EPA consults with State and local government officials early in the process of developing the proposed regulation. EPA also may not issue a regulation that has federalism implications and that preempts State law, unless the Agency consults with State and local government officials early in the process of developing the proposed regulation.

Section 4 of the Executive Order contains additional requirements for rules that preempt State or local law, even if those rules do not have federalism implications (i.e., the rules will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government). Those requirements include providing State and local government officials notice and an opportunity for appropriate participation in the development of the regulation. If the preemption is not based on express or implied statutory authority, EPA also must consult, to the extent practicable, with appropriate State and local government officials regarding the conflict between State law and federally protected interests within the agency's area of regulatory responsibility.

This proposed rule does not have federalism implications. This proposal would amend the existing WPR to cover additional asbestos-related activities and to bring the WPR into conformance with recent changes to the OSHA Asbestos Standards. The proposed changes are not expected to result in a significant intergovernmental mandate under the UMRA, and thus, EPA concludes that the rule would not impose substantial direct compliance costs. Nor would the rule substantially affect the relationship between the national government and the States, or the distribution of power and responsibilities among the various levels of government. Those relationships have already been

established under the existing WPR, and these amendments would not alter them. Thus, the requirements of section 6 of the Executive Order do not apply to this proposed rule.

This proposed rule would preempt State and local law in accordance with TSCA section 18(a)(2)(B). By publishing and inviting comment on this proposed rule, EPA hereby is providing State and local government officials notice and an opportunity for appropriate participation. Thus, EPA has complied with the requirements of section 4 of the Executive Order.

F. Consultation and Coordination with Indian Tribal Governments

Under Executive Order 13084, entitled *Consultation and Coordination with Indian Tribal Governments* (63 FR 27655, May 19, 1998), EPA may not issue a regulation that is not required by statute, that significantly or uniquely affects the communities of Indian tribal governments, and that imposes substantial direct compliance costs on those communities, unless the Federal government provides the funds necessary to pay the direct compliance costs incurred by the tribal governments, or EPA consults with those governments.

This rule does not significantly or uniquely affect the communities of Indian tribal governments, nor does it impose substantial direct compliance costs on such communities. Since the OSHA Asbestos Standards cover tribal governments and tribal employees, the WPR does not apply to these groups (Ref. 24.). Accordingly, the requirements of section 3(b) of Executive Order 13084 do not apply to this proposed rule.

G. Environmental Justice

Pursuant to Executive Order 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629, February 16, 1994), the Agency has considered environmental justice-related issues with regard to the potential impacts of this action on the environmental and health conditions in minority and low-income populations. As discussed above in Unit II.B.1.e., many of the employees who would benefit from the protections of this proposed rule are members of minority and low-income populations. By providing protection for currently unprotected State and local government building maintenance and custodial employees and their families, this rule would address the lesser levels of protection in the workplace experienced by minority and low-income populations among State and local

government employees. In other words, the proposed rule would not impose disproportionately high and adverse human health or environmental effects on minority or low-income populations, but would actually decrease such effects.

Public participation is an important environmental justice concern. EPA encourages State and local government employees, and organizations representing them, to participate in this rulemaking process by submitting comments (see Unit I.C.). In addition, interested persons or organizations may request that EPA hold an informal public hearing on this proposed rule, at which they may present oral comments (see Unit I.C.3.). If EPA decides to hold an informal hearing, it will publish a notice in the **Federal Register** announcing the time, place, and date of the hearing, explaining how interested persons or organizations can request to participate in the hearing, and describing the hearing procedures.

EPA has considered the comments submitted on its November 1, 1994, proposal in developing this modified proposal. Labor organizations representing State and local government employees were among the commenters. EPA also met with those organizations prior to developing this modified proposal.

H. Children's Health

Executive Order 13045, entitled *Protection of Children from Environmental Health Risks and Safety Risks* (62 FR 19885, April 23, 1997), does not apply to this proposed rule because it is not "economically significant" as defined under Executive Order 12866. However, it is EPA's policy to consistently and explicitly consider risks to infants and children in all risk assessments generated during its decisionmaking process, including the setting of standards to protect public health and the environment.

EPA has determined that children are physiologically more vulnerable to asbestos exposures than adults, and that this rule would prevent approximately 65.65 cancer cases among persons with childhood exposures to asbestos from school buildings. EPA also expects that this proposed rule would result in other benefits associated with lower asbestos exposures, such as a reduced incidence of non-cancerous health effects such as asbestosis, pleural plaques, and pleural effusion. EPA expects the proposed rule to substantially benefit children by reducing the incidental exposures children face while attending affected schools. By reducing ambient asbestos concentrations in school buildings, this

rule would help protect children from the disproportionate asbestos exposure risk they face. Additional details are contained in Unit II.B.1.f. and in the Economic Analysis (Ref. 18).

I. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA), Public Law 104-113, section 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies. The NTTAA directs EPA to provide Congress, through OMB, explanations when the Agency decides not to use available and applicable voluntary consensus standards.

This rulemaking involves several technical standards and EPA has searched for potentially applicable voluntary standards. The results of this search are described in this unit. However, EPA's primary goal in proposing these amendments to the WPR is to achieve consistency with the 1994 OSHA Standards. As noted elsewhere in this preamble, EPA has determined that having different standards for public and private sector workers is inefficient and unfair, and that EPA should generally defer to OSHA's expertise in the matter of worker protection. Therefore, EPA finds that any voluntary consensus standard which is inconsistent with the applicable OSHA Standards is impractical under NTTAA section 12(d)(3).

One of the technical standards in the WPR is the method for analyzing personal air monitoring samples. Under the 1987 WPR, personal air monitoring samples must be analyzed using the method prescribed in Appendix A to 40 CFR 763.121 (phase-contrast microscopy) or an equivalent method. The 1994 OSHA Standards, which this proposal would adopt by cross-reference, contain the identical requirement and analytical method. EPA has performed a search to identify any potentially applicable voluntary consensus standards, but is unable to identify any alternatives to the current method of analysis. In addition, as discussed in Unit II.A.2.d., EPA's 1994 proposal would have allowed an alternative PEL based on personal air monitoring samples analyzed through

transmission electron microscopy. Commenters called into question the scientific basis for setting the alternative PEL and, as a result, EPA is withdrawing that portion of its 1994 proposal.

These amendments to the WPR adopt specific engineering controls and work practices, which could be considered a technical standard for conducting asbestos construction work and brake and clutch repair operations. EPA has identified several voluntary consensus documents that address aspects of the proper performance of asbestos abatement actions and asbestos operations and maintenance activities. The National Institute of Building Sciences (NIBS) has developed two documents to assist building owners and employers who are performing asbestos abatement and operations and maintenance projects. "Asbestos Abatement and Management in Buildings, Model Guide Specifications" (Ref. 25), is designed to be used as a guide to developing appropriate contract specifications. In addition to particular provisions for minimizing worker exposure to asbestos, the comprehensive "Model Guide" includes specifications for all other aspects of worker safety and fire prevention, as well as general contract language establishing the rights and responsibilities of the contractor and building owner.

NIBS has also developed guidance materials for building operations and maintenance projects that involve asbestos-containing materials. The "Guidance Manual, Asbestos Operations and Maintenance Work Practices" (Ref. 26), is designed to help the building owner or employer properly manage in-place asbestos-containing materials. The "Manual" contains extensive recommendations, including sample checklists and forms, on the administration of a building operations and maintenance program. The "Manual" also provides explicit guidance on how to protect workers and building occupants from asbestos exposure during normal building maintenance activities such as pipe repair, wiring installation, and floor cleaning and polishing.

EPA highly recommends the use of these NIBS documents for building owners and employers. Both of these documents were revised in 1996 to reflect the 1994 amendments to the OSHA Standards, and EPA believes that the use of these documents would facilitate compliance with the asbestos abatement and building operations and maintenance requirements in the proposed WPR. However, since each of

these documents are extremely detailed and encompass many circumstances beyond the scope of this rulemaking, EPA does not believe that it is practical or appropriate to incorporate these consensus documents into the WPR. In addition, the Preface to the "Guidance Manual" explicitly states that this particular document is not intended to be used for regulatory purposes.

The American Society for Testing and Materials (ASTM) has developed two potentially applicable documents: "Standard Practice for Visual Inspection of Asbestos Abatement Projects" (Ref. 27), and "Standard Practice for Encapsulants for Spray-or-Trowel-Applied Friable Asbestos-Containing Building Materials" (Ref. 28). The ASTM documents also represent state-of-the-art knowledge regarding the performance of these particular aspects of asbestos abatement and operations and maintenance activities, and EPA highly recommends their use. However, as with the NIBS documents, EPA is not proposing to incorporate them into the WPR because, in many instances, the specifications are more comprehensive and rigorous than the requirements of the current OSHA standard. As a result, EPA has determined that adoption of the ASTM and NIBS documents would be impractical under NTTAA section 12(d)(3).

Finally, EPA is proposing to adopt by cross-reference the appropriate provisions of the OSHA Respiratory Protection Standard at 29 CFR 1910.134. As discussed in Unit II.A.2.j., the OSHA Respiratory Protection Standard establishes comprehensive requirements for the selection, use, and maintenance of respirators. When this Standard was amended in 1998, OSHA incorporated nearly all of the provisions of the ANSI Z88.2-1992 respiratory protection standard, a voluntary consensus standard (Ref. 29). OSHA's limited number of departures from the ANSI standard involved instances where OSHA determined on the record that the ANSI standard was either insufficiently protective or unduly burdensome. The preamble to the OSHA Respiratory Protection Standard (Ref. 14, pp.1152-1300) discusses in detail the differences between the OSHA Standard and the ANSI standard. EPA agrees with OSHA's analysis on the incorporation of the ANSI standard. Therefore, by proposing to adopt, by cross-reference, the revised OSHA Respiratory Protection Standard, EPA is incorporating a voluntary consensus standard to the maximum practical extent under the NTTAA.

EPA welcomes comments on this aspect of the proposed rulemaking. The

public is specifically invited to identify potentially applicable voluntary consensus standards and to explain why the benefits of using such standards in this regulation would outweigh the problems associated with promulgating a worker protection regulation that differs from the OSHA Standards.

J. Constitutionally Protected Property Rights

EPA has complied with Executive Order 12630, entitled *Governmental Actions and Interference with Constitutionally Protected Property Rights* (53 FR 8859, March 15, 1988), by examining the takings implications of this rule in accordance with the "Attorney General's Supplemental Guidelines for the Evaluation of Risk and Avoidance of Unanticipated Takings" issued under the Executive Order.

K. Civil Justice Reform

In issuing this rule, EPA has taken the necessary steps to eliminate drafting errors and ambiguity, minimize potential litigation, and provide a clear legal standard for affected conduct, as required by section 3 of Executive Order 12988, entitled *Civil Justice Reform* (61 FR 4729, February 7, 1996).

List of Subjects in 40 CFR Part 763

Environmental protection, Asbestos, Schools, Hazardous substances, Reporting and recordkeeping requirements, Worker protection.

Dated: April 20, 2000.

Carol M. Browner,
Administrator.

Therefore, it is proposed that 40 CFR chapter I, subchapter R, be amended as follows:

PART 763—[AMENDED]

1. The authority citation for part 763 would continue to read as follows:

Authority: 15 U.S.C. 2605, 2607(c), 2643, and 2646.

2. By revising § 763.91(b) to read as follows:

§ 763.91 Operations and maintenance.

* * * * *

(b) *Worker protection.* See subpart G of this part.

* * * * *

Appendix B to Subpart E [Removed and reserved]

3. By removing and reserving Appendix B to subpart E.

4. By revising subpart G to read as follows:

Subpart G—Asbestos Worker Protection

Sec.

763.120 What is the purpose of this subpart?

763.121 Does this subpart apply to me?

763.122 What does this subpart require me to do?

763.123 May a State implement its own asbestos worker protection plan?

Subpart G—Asbestos Worker Protection**§ 763.120 What is the purpose of this subpart?**

This subpart protects certain State and local government employees who are not protected by the Asbestos Standards of the Occupational Safety and Health Administration (OSHA). This subpart applies the OSHA Asbestos Standards in 29 CFR 1910.1001 and 29 CFR 1926.1101 to these employees.

§ 763.121 Does this subpart apply to me?

If you are a State or local government employer and you are not subject to a State asbestos standard that OSHA has approved under section 18 of the Occupational Safety and Health Act or a State asbestos plan that EPA has exempted from the requirements of this subpart under § 763.123, you must follow the requirements of this subpart to protect your employees from occupational exposure to asbestos.

§ 763.122 What does this subpart require me to do?

If you are a State or local government employer whose employees perform:

(a) Construction activities identified in 29 CFR 1926.1101(a), you must:

(1) Comply with the OSHA standards in 29 CFR 1926.1101.

(2) Submit notifications required for alternative control methods to the Director, National Program Chemicals Division (7404), Office of Pollution Prevention and Toxics, Environmental Protection Agency, Ariel Rios Bldg., 1200 Pennsylvania Ave., NW., Washington, DC 20460.

(b) Custodial activities not associated with the construction activities identified in 29 CFR 1926.1101(a), you must comply with the OSHA standards in 29 CFR 1910.1001.

(c) Repair, cleaning, or replacement of asbestos-containing clutch plates and brake pads, shoes, and linings, or removal of asbestos-containing residue from brake drums or clutch housings, you must comply with the OSHA standards in 29 CFR 1910.1001.

§ 763.123 May a State implement its own asbestos worker protection plan?

This section describes the process under which a State may be exempted from the requirements of this subpart.

(a) *States seeking an exemption.* If your State wishes to implement its own asbestos worker protection plan, rather than complying with the requirements of this subpart, your State must apply for and receive an exemption from EPA.

(1) *What must my State do to apply for an exemption?* To apply for an exemption from the requirements of this subpart, your State must send to the Director of EPA's Office of Pollution Prevention and Toxics (OPPT) a copy of its asbestos worker protection regulations and a detailed explanation of how your State's asbestos worker protection plan meets the requirements of TSCA section 18 (15 U.S.C. 2617).

(2) *What action will EPA take on my State's application for an exemption?* EPA will review your State's application and make a preliminary determination whether your State's asbestos worker protection plan meets the requirements of TSCA section 18.

(i) If EPA's preliminary determination is that your State's plan does meet the requirements of TSCA section 18, EPA will initiate a rulemaking, including an opportunity for public comment, to exempt your State from the requirements of this subpart. After considering any comments, EPA will issue a final rule granting or denying the exemption.

(ii) If EPA's preliminary determination is that the State plan does not meet the requirements of TSCA section 18, EPA will notify your State in writing and will give your State a reasonable opportunity to respond to that determination.

(iii) If EPA does not grant your State an exemption, then the State and local government employers in your State are

subject to the requirements of this subpart.

(b) *States that have been granted an exemption.* If EPA has exempted your State from the requirements of this subpart, your State must update its asbestos worker protection regulations as necessary to implement changes to meet the requirements of this subpart, and must apply to EPA for an amendment to its exemption.

(1) *What must my State do to apply for an amendment?* To apply for an amendment to its exemption, your State must send to the Director of OPPT a copy of its updated asbestos worker protection regulations and a detailed explanation of how your State's updated asbestos worker protection plan meets the requirements of TSCA section 18. Your State must submit its application for an amendment within 6 months of the effective date of any changes to the requirements of this subpart, or within a reasonable time agreed upon by your State and OPPT.

(2) *What action will EPA take on my State's application for an amendment?* EPA will review your State's application for an amendment and make a preliminary determination whether your State's updated asbestos worker protection plan meets the requirements of TSCA section 18.

(i) If EPA determines that the updated State plan does meet the requirements of TSCA section 18, EPA will issue your State an amended exemption.

(ii) If EPA determines that the updated State plan does not meet the requirements of TSCA section 18, EPA will notify your State in writing and will give your State a reasonable opportunity to respond to that determination.

(iii) If EPA does not grant your State an amended exemption, or if your State does not submit a timely request for amended exemption, then the State and local government employers in your State are subject to the requirements of this subpart.

[FR Doc. 00-10517 Filed 4-26-00; 8:45 am]
BILLING CODE 6560-50-F

Appendix N

Key Personnel Resumes

Richard C. Guglomo, P.E.

Civil Engineer

Education

MS, Civil Engineering, San Jose State University, 1968
BS, Civil Engineering, Washington State University, 1964

Registration

Civil and Sanitary Engineer, Washington
Civil Engineer, Arizona, California, Illinois, Iowa, Kansas, Missouri, Montana, Nebraska,
New Mexico, Oregon

Professional Summary

Mr. Guglomo's career has spanned a broad range of engineering activities. In addition to extensive design work, he has conducted investigations and participated in construction management as a resident engineer and a project manager.

Mr. Guglomo has 40 years of varied background experience in civil engineering practice. His chief area of expertise is the design of new and the expansion of existing facilities, and the complete design of the various infrastructure facilities associated with such installations. Mr. Guglomo has managed the preparation of numerous facility plan studies. He is an experienced design team coordinator bringing all of the project disciplines together to produce a smooth project completion. Mr. Guglomo is also experienced in the preparation of Process and Instrumentation Diagrams for projects, usually preparing the first draft of these drawings for use by the electrical/instrumentation engineers.

Mr. Guglomo has been engaged for the last nine years in design and construction of over \$50M of railroad facilities.

Relevant Project Experience

- *Construction Coordinator for Recent Projects – BNSF Various.* Construction Coordinator for the following recent BNSF projects:
 - Fueling Facilities at Murray Yard in North Kansas City, Missouri (\$3.5M)
 - Wastewater Treatment Plant at Murray Yard (\$3.5M)
 - Wastewater Treatment Plant at Alliance Nebraska (\$2M)
 - Wastewater Treatment Plant at Gallup, New Mexico (\$1.5M)
 - Wastewater Treatment Plant at Belen, New Mexico (\$2M)
 - Butte/Silverbow Superfund Cleanup at Butte, Montana (\$3.5M)
- *Project Manager and Construction Coordinator – BNSF Clyde Yard, Cicero, Illinois.* Project Manager for the redesign of Diesel Shop Electrical and HVAC, Salt Storage Shed Demolition and Rehabilitation, Trackage Redesign, and Electrical and Instrumentation for the DFO Fueling Facilities. BNSF designed the improvements for

the Clyde Yard in 1991. By the time the project went to bid in early 1998, major portions of the project were obsolete and in need of redesign. The existing trackage had been modified and the design to fit the new facilities into the existing had to be revised. Kennedy/Jenks Consultants revised the design and lowered the trackage construction cost from \$5M to \$3M.

Project Manager for the design of a new sanding system to fill sandboxes of locomotives with track sand. This design was an off-the-shelf design using easily available components. The design was copied and upgraded from facilities at CSX and Norfolk Southern in Birmingham, Alabama.

Construction Coordinator for the bidding, award, and construction management of the Clyde Yard Facilities. This project was constructed during 1998 and 1999. The facilities were started up in late 1999.

- *Construction Manager for Upgrades – BNSF Clyde Yard, Cicero, Illinois.* Kennedy/Jenks Consultants performed construction of upgrades to the Clyde Yard facilities. These upgrades were requested by the General Foreman at Clyde Yard and consist of piping, operational, and modifications to new facilities constructed in 1998 and 1999.
- *Project Engineer for Fueling Facility Design – BNSF Sioux City, Iowa.* Design of a new single track fueling facility to replace the existing facilities at Sioux City. The facilities consist of a new tank farm with two each 125,000 gallon DFO storage tanks, a lined secondary containment basin for the DFO tanks, a new Lube Oil tank, a new Used Oil tank, a new DFO and Lube Oil Pump Station to pump DFO and Lube Oil to the fueling platform, a new Utilidor for piping from the pump station to the fueling platform, a new single track fueling platform with features to expand it to two tracks in the future, and a new wastewater treatment system.

The project has been completed except for installation of the equipment. Currently the facility is being used as a Direct To Locomotive (DTL) fueling facility. New track to move Consists from the yard onto the platform is in place.

After completion of Phase 2, a new Sand Towers was erected north of the new fueling platform.

- *Project Engineer for Fueling Facility Preliminary Design – BNSF Temple, Texas.* Project Engineer for the design of new fueling facilities for the yard in Temple Texas. A 35 percent design was prepared including a definitive level cost estimate. After evaluating the cost the project was postponed for completion to the future.
- *Project Manager for Small Projects – BNSF Various Locations.* Several projects on the west coast, including sand system rehabilitation at Barstow, California, a new sand system at Spokane, Washington, fueling facility upgrade at Interbay in Seattle, Washington, building expansion in Vancouver, Washington, double contained DFO piping at Interbay in Seattle, new exit door for the diesel shop at Interbay in Seattle, and a new sand tower at the yard in Everett, Washington.

Charles Soule, R.G.

Senior Hydrogeologist

Education

MS, Geology/Hydrogeology, Western Michigan University, 1988
MS, Geoscience/Geomorphology, University of Arizona, 1978
BA, Geology, Miami University of Ohio, 1972

Registration

Registered Geologist, California
Licensed Hydrogeologist, Washington

Professional Summary

Mr. Soule is a Registered Geologist with more than 20 years experience applying surface and subsurface geological interpretation to environmental and natural resource projects. He has managed investigations and remedial designs for sites throughout the United States involving surface and subsurface transport of hazardous substances. He has designed and implemented groundwater monitoring programs for both municipal water supply and hazardous substance projects, including design and implementation of remedial actions for industrial properties, landfills, and UST sites. Mr. Soule has managed remediations involving soil capping, soil bioremediation, vapor extraction systems, and groundwater remediation systems at numerous sites. In addition to his geological expertise, Mr. Soule is knowledgeable in historical practices of the railroad industry.

Currently, Mr. Soule is managing design and implementation of a response action for railroad beds impacted by mining wastes at a major Superfund Site in Montana. This project has required capping of more than 16 acres of mining impacted railbed and adjacent land with soil or rock caps, construction of 1 lined and 3 unlined stormwater retention basins, and construction of a repository for 27,000 cubic yards of mining-impacted materials. For this project, he is also participating in management of the RI/FS on behalf of some of the PRPs and provides technical support for allocation negotiations among the site PRPs. He is also currently conducting characterization of fuel releases at three railroad yards.

Prior to joining Kennedy/Jenks, Mr. Soule conducted wellhead protection investigations for several large water districts, and managed independent remedial actions at numerous sites, usually involving bioremediation of soil containing petroleum hydrocarbons. His Master's Thesis investigated magnitudes of prehistoric earthquakes in Arizona.

Representative Project Experience

- Project Manager for preparing an evaluation of conceptual response options for a railyard in Montana with soil containing asbestos. This project evaluated several capping and removal options for soil within the track structure. Conceptual designs were developed for the options, and they were compared based on overall protection of human health and the environment, compliance with action levels, short-term and long-term effectiveness, reduction of toxicity, mobility and volume,

Implementability, and cost effectiveness. Based on the results of the evaluation, the preferred option is currently under fast track design for bidding and construction.

- Project Manager for two major railroads regarding technical issues related to railroad beds impacted by mining waste at a mining-related Superfund site in Butte, Montana. Major contaminants of concern include metals and arsenic in soil and groundwater. This project has been ongoing for several years, and have included the following activities:
 - Conducted a complex environmental characterization of the railbeds.
 - As technical representative for the two railroads, participates with other PRPs to oversee preparation of an RI/FS by another contractor.
 - As technical representative for the two railroads, participated with other PRPs to provide appropriate exposure input and review Risk Assessments for human health and for environmental risk prepared by an EPA contractor.
 - As technical representative for the two railroads, assists with technical aspects of allocation negotiations both between the railroads and between the railroads and the other PRPs.
 - Oversaw design of response actions for railbeds owned/operated by the two railroads and another PRP, and implementation of those response actions for railbeds owned/operated by the two railroads.
- Project Manager for site characterizations of three railroad yards in Montana and North Dakota with subsurface releases of diesel fuel resulting from historic site activities. Site activities have included review of historical site facilities, subsurface soil sampling, installation and sampling of substantial monitoring well networks, assistance in preparation of Human Health Risk Assessments for two of the sites, and participation in continuing regulatory negotiations for implementation of voluntary site cleanup plans utilizing intrinsic bioremediation.
- Technical consultant for reviewing Remedial Design, regulatory liaison and preparing arbitration submittals for contaminated sediments in a marine waterway at a Superfund site in Tacoma, Washington. Major contaminants of concern include carcinogenic PAHs and other organic compounds. The client, a major railroad, operated a drawbridge, a small railyard, and a fueling facility in the vicinity of the waterway for about 75 years. Representative Project Experience with Previous Employer
- Project manager for RI/FS/RD at a former railroad maintenance facility in Tacoma, WA. Activities included site and contaminant transport characterization, groundwater modeling, field and bench scale treatability studies for petroleum hydrocarbon contaminated soil, and FS preparation.
- Assessed petroleum hydrocarbon contamination associated with a historic bulk fuel facility located on property owned by the client. Bioremediated approximately 1,600 cubic yards of diesel-contaminated soil in six weeks, and closed the site as an independent remedial action under Washington's Model Toxics Control Act.

David A. Diem, P.G.

Construction Manager/Senior Geologist

Education

Bachelor of Science, Geology, San Diego State University, 1982
Graduate Studies, Geology, Montana State University, 1985
Asbestos Safety I & II, Safety Specialists, 1986
Fundamentals of Gas Chromatography, Varian Corporation, 1987
OSHA 40-Hour, Health and Safety Course (Standard & Supervisor)
OSHA Certification as "Competent Person" for Trenching and Shoring

Registration

Registered Environmental Assessor, California, #00499

Professional Summary

Dave Diem currently serves as a Kennedy/Jenks Engineers Project Manager. Dave has been a practicing professional in the construction, hazardous waste and environmental industry for nearly 20 years. He has particular expertise in the area of construction management, and in 2003 completed construction management services for construction of a water treatment plant in Northern California, and an industrial waste water treatment plant for BNSF in Barstow, CA. In addition, in 2001 and 2002, Dave completed a two-year commitment as the onsite Construction Manager for Kennedy/Jenks for a large EPA Superfund cleanup site for BNSF in Butte, Montana. He has established himself within the Southern California community as evidenced by his previous position as Construction Project Manager of Environmental Services for PTES while working on a large 7-year Environmental Job Order Contract (EJOC) with the U.S. Navy in San Diego. In that capacity, Dave managed many construction and demolition projects at virtually every military installation in Southern California.

Mr. Diem has managed multi-million dollar projects throughout the western United States (including Alaska) that have involved: site remediation, asbestos and lead mitigation, water and waste water facilities construction, construction and remediation of mining wastes, UST removal, UST installation, large-scale soil and groundwater bio-remediation, installation of groundwater treatment systems, and demolition of large government facilities.

Relevant Project Experience

- Asbestos and lead remediation of large multi-building facility for the U.S. Navy at the former Miramar Naval Air Station (Top Gun School). Project involved containment and removal of friable asbestos containing material (ACM). In addition to removal and disposal of ACM floor and ceiling tiles, large quantities of paint containing lead was also removed. This project was approximately a year in implementation, involved many buildings and barracks, and was performed under the U.S. Navy's Installation and Restoration Program (IRP).

- Asbestos and lead removal during demolition of the “Old Fire Fighting School” at the Naval Station, San Diego (32nd Street). The Project involved demolishing the largest military fire fighting facility in the United States. The ACM was primarily friable, and was found in duct work, floor tiles, ceiling tiles, pipe wrap and other insulation. The removal activities lasted approximately 1 and ½ -years. This work was also performed as part of the Navy’s IRP program.
- Resident Construction Manager for remediation and mitigation of impacted soil and surface water derived from wastes produced during mining activities in Butte, Montana. The project was performed for two Class I Railroads, and was accomplished under the direction of the EPA, and is part of the Silver Bow Creek/Butte Area National Priority List (NPL) Site. The soil and surface water impacts consisted of arsenic, copper, lead and zinc. Remediation activities included construction of approximately 5,000 linear feet of surface water diversion ditches; construction of three impoundment basins totaling over 10-acres in surface area; reclamation of approximately 16-acres of revegetation, rock capping, or cellular confinement (honeycomb geotextile and rock) caps on steep slopes; and construction of a soil repository that currently is storing and capping approximately 27,000 cubic yards of impacted soil and mining waste rock.
- Resident Construction Manager/Resident Engineer for demolition and rebuild of an industrial wastewater treatment plant (IWWTP) for a Class I Railroad Company. Work entailed complete demolition of two thirds of an existing IWWTP, and rebuilding a new state of the art facility. The project included installation of a new dissolved air flotation tank, two 15,000-gallon sludge holding tank, two 20,000-gallon oil sludge tanks, sand filter tanks, re-coating the 900,000-gallon equalization tank, construction of evaporation ponds, and all related work to produce a state of the art operating facility. The work was scheduled to be performed in 7-months, and was finished on time and within project budget. As the Construction Manager, Dave was responsible for all day to day activities, including daily safety briefings, scheduling, project cost analyses, inspection of completed work, direct oversight of the prime contractor, interface with the local regulatory agencies, and interface with the clients representatives.
- Resident Construction Manager/Resident Engineer for construction of a new water treatment plant for a small water district in Northern California. The work started at the end of 2002, and was completed by May of 2003. The work entailed oversight of a prime contractor who was responsible for construction of a new small operating plant from the ground up. Dave was responsible for daily oversight of installation of all mechanical elements, construction of the new building, installation of fencing, landscaping, concrete work, and all applicable Fire Department requirements.
- Resident Construction Manager for construction of a lined containment lagoon located in Gallup, New Mexico. The project was performed for a Class I Railroad in support of mitigation of impacted storm water runoff from a rail yard operation. The project consisted of construction of the HDPE lined lagoon (approximate combined surface area of 1/2-acre), and installation of diversion channels.

- Resident Construction Manager for construction of two lined containment lagoons located in Temple, Texas. The project was performed for a Class I Railroad in support of mitigation of impacted storm water runoff from a rail yard operation. The project consisted of construction of two HDPE lined lagoons (approximate combined surface area of 2-acres), installation of new oil/water separator, and installation of diversion channels.
- Provided Construction Management to a project involving the blasting, repair and lining of thirteen 500,000-gallon USTs at the Naval Air Station, North Island. The USTs supplied all fuel to the aircraft carriers and jet airplanes.
- Construction oversight for construction of two Navy Exchange service stations and for the removal and installation of four large capacity USTs
- Construction Management of the demolition and site preparation of the Old Firefighting Training Facility at the Naval Air Station, San Diego. Work involved demolition of a three-story stainless steel "burn-building," crew's quarters, and office buildings. All out-buildings contained asbestos and lead. In addition, work included removal of 12 USTs of various sizes, removal of a 1,000-foot long/6-inch diameter, JP-5 pipeline, and installation of a dual-phase groundwater/vapor recovery system.
- Construction oversight of the removal of approximately 50 USTs of various sizes in various locations.
- Construction Management of soil remediation of a large diesel spill for an agricultural facility located in Meridian, California. The project involved excavation and removal of impacted soils and groundwater; set-up of the onsite treatment facility, soil and groundwater sampling and analysis, overseeing the application of specially formulated bio-cultures, operational consultation and regulatory compliance.
- Subsurface assessment and remediation for a former Texaco service station in Lodi, California. The project involved a soil gas survey, soil boring and groundwater monitoring well installation, soil and groundwater sampling and analysis, feasibility study presenting remedial action options, operational consultation and regulatory compliance.
- Oversight of soils/groundwater assessment and remediation of a large multi-UST site in Grass Valley, California. The project involved excavation and removal of hydrocarbon-impacted soils and groundwater, set-up of onsite treatment facility, soil and groundwater sampling and analysis, operational consultation and regulatory compliance.
- Oversight of soils/groundwater assessment and remediation for a multi-UST site located on a large sod growing facility in Davis, California. The project involved excavation and removal of hydrocarbon-impacted soils and groundwater, set-up of the onsite treatment facility, soil and groundwater sampling and analysis, operational consultation and regulatory compliance.

Experience Profile

Tanya L. Drake

Senior Geologist/Operations Manager - Minneapolis

EDUCATION

B.S. Earth Science - Geology, Saint Cloud State University

TRAINING/CERTIFICATIONS

IA Certified Groundwater Professional #1949
40 Hour OSHA Training per 1910.120
40 Hour NIOSH 582-E
24 Hour Minnesota Asbestos Building Inspector
40 Hour Minnesota Asbestos Site Supervisor
Minnesota Air Monitoring Technician Course
Radiation Safety and Measurement Technology
Red Cross First Aid Training
Red Cross CPR Training
8 Hour On-Track Safety

PROFESSIONAL AFFILIATIONS

Minnesota Groundwater Association

FIELDS OF SPECIALIZATION

Site Investigations
Regulatory Permitting
Regulatory Reporting (RCRA, TSCA, AHERA)
Compliance Audits (SPCC, SWPP)
Subsurface Investigation
Groundwater Modeling
Asbestos Project Oversight

QUALIFICATIONS SUMMARY

Ms. Drake is a solid project manager and technical assistant with strong developmental and organizational skills and ten years of real-time experience. She has served as project manager on various storage tank sites for retail petroleum, government, and railroad clients. Her field responsibilities have included collecting and field screening soil and water samples, performing aquifer pumping and slug tests, surveying, trouble shooting equipment maintenance, overseeing well installation, tank removal, soil excavation, as well as reporting to clients and regulatory agencies.

- Aquifer analysis and data collection using data logging, Aqtesolv and BRR Slug.
- Field sample and data collection.
- Interpretation of field data and preparation of reports and proposals for client and regulatory agency use.
- Geology laboratory support services; including core sample analysis, well-logging, drill mud analysis, and total organic carbon testing.
- Asbestos inspection and abatement oversight
- Vermiculite in soils inspection, sampling, and removal oversight.
- Hazardous Waste Management
- Compliance audits for SPCC and SWPP

Ms. Drake has served as Field Geologist or Project Manager for more than 100 petroleum-impacted sites in Minnesota, Wisconsin, Iowa, Nebraska, North Dakota, and South Dakota.

SELECTED PROJECTS

Soil Excavation for Asbestos Contaminated Soils, Minot, North Dakota,

Project Manager This project involved the removal of 700 cubic yards of asbestos contaminated soils from railroad right-of-way in Minot, North Dakota. The United States Environmental Protection Agency (USEPA) conducted preliminary testing and delineation. Ms. Drake worked with the USEPA when planning and executing the project in order to comply with the processes and procedures set forth by the USEPA. EMR coordinated and oversaw the removal of the asbestos contaminated soils at the site. EMR conducted soil sampling and air monitoring associated with this project. Upon completion of the project,

Ms. Drake prepared the final report for submittal to the USEPA on behalf of EMR's railroad client. The EPA granted the site regulatory closure in the fall of 2003.

Heavy Metal in Soils and Asbestos Inspection/Air Monitoring, Arden Hills, Minnesota.

Project Manager This project involved field screening heavy metals analysis in soils at a former Army Ammunitions facility in Arden Hills, Minnesota. Ms. Drake has been responsible for project management activities including scheduling of personnel, establishing protocol and dealing with client concerns and issues. EMR has utilized multiple dual-source XRF units to provide real-time field screening results to the contractor for the past four seasons. EMR also provided asbestos inspection and asbestos air monitoring services associated with un-permitted landfills located on site during excavation activities. Ms. Drake has been involved with the project in most aspects including management and providing relief operations for project personnel.

Asbestos and Petroleum Impacted Soil Excavation, St. Paul, Minnesota:

Program Manager This project involved removal of 4,000 cubic yards of asbestos and petroleum impacted soil. Soil removal was required for a building project scheduled on site; the site is a railroad museum. EMR conducted soil screening for petroleum hydrocarbons and visual inspection for asbestos. The sources of the asbestos on site were buried insulated pipes. Ms. Drake provided program management and also served as primary field person on site providing air monitoring and inspection activities.

Crosby Lake Business Park, St. Paul, Minnesota:

Staff Geologist, Field Geological Investigation Team responsibilities include assisting the geological investigation in site characterization, regulatory interpretation, groundwater modeling, and remediation. The site historically operated as a bulk storage facility/tank farm for Texaco. The investigation determined the type, amount and extent of environmental hazards present at the site; the risk assessment established cleanup levels. Ms. Drake served as on site field supervisor for three seasons. Remedial activities included excavation of impacted overburden for thermal treatment, land farming, and landfilling. She also conducted groundwater sampling associated with petroleum hydrocarbon impacts to the sandstone bedrock aquifer. Upon completion of field activities, the site was redeveloped by the St. Paul Port Authority. Impacts at the site included petroleum hydrocarbons and lead. Ms. Drake was completing remediation on behalf of the client under Minnesota's Voluntary Investigation and Cleanup (VIC) Program for another consulting firm.

Environmental Compliance Management, Upper Mid-West

Project Manager These projects have involved efforts in most aspects of environmental compliance and waste management for multiple railroad clients. Topics of compliance covered under these program management responsibilities included; regulatory review, incident response, response planning, storm water management, waste management, training, asbestos management, tank management, wastewater treatment, air permitting, and noise related issues. Many other aspects of compliance and waste management are covered under these programs as well, including material management and recycling efforts.

Coastal Mart, Inc.

Project Manager for numerous LUST sites for Coastal Mart, Inc. sites located in Iowa, South Dakota, and Minnesota. Provided project oversight and field activities at approximately 80 sites in Iowa; completing Tiered RBCA Site Assessment Reports, periodic Site Cleanup Reports, Tank Closure Reports, Free Product Recovery Reports, and Site Closure Reports, as warranted, for all Iowa sites. Ms. Drake has been involved in the LUST site management program for Coastal beginning in 1995 as a Staff Geologist.

Phase I Site Investigation

Project Supervisor for the assessment of various properties, while with another consulting firm, for government and industry clients including US West, General Motors, and the Minneapolis Community Development Agency. Ms. Drake was responsible for data collection and site investigation for property transfer. Responsibilities included contacting government agencies to gather information related to spill history, endangered species, Native American historical properties, zoning, and history of the parcel. Field activities included the inspection for items of concern including transformers, storage tanks, spill evidence, building usage, and product usage.

Experience Profile
David L. Welch
Project Geologist

EDUCATION

B.S. Geology, Western Washington University, Bellingham, WA, 1984

REGISTRATIONS/ CERTIFICATIONS

International Fire Code Institute-Certified Washington UST Site Assessor
AHERA Asbestos Building Inspector
AHERA Asbestos Management Planner
AHERA Asbestos Abatement Contractor/Supervisor
AHERA Asbestos Project Designer
California-OSHA Certified Asbestos Consultant
NIOSH 582 Course: Sampling and Evaluating Airborne Asbestos Dust
EPA-Accredited Lead Inspector/Risk Assessor Training Course
NITON XRF 7000 Series Training Course
EPA Lead Risk Assessor (WA, AK, ID, NE)
Oregon Lead Risk Assessor

FIELDS OF SPECIALIZATION

- ◆ Asbestos Project Design
- ◆ Asbestos Operation and Maintenance (O&M) Plans
- ◆ Asbestos Operation and Maintenance (O&M) 16 hour Training Course Instructor
- ◆ Asbestos Building Inspections and Abatement Oversight
- ◆ Asbestos Air Monitoring and PCM Analysis by NIOSH 7400
- ◆ Computer Aided Drafting (CAD)
- ◆ Lead-based paint Inspections/Risk Assessments
- ◆ Hydrocarbon Assessment/Remediation
- ◆ State RCRA Program: Model Toxics Control Act (MTCA) Cleanup Regulation Program, State of Washington: Remedial Investigation/Feasibility Studies (RI/FS)
- ◆ Independent Remedial Action Process (IRAP)
- ◆ Dangerous Waste Manifests
- ◆ Phase I Environmental Site Assessments under ASTM "Due Diligence"
- ◆ Phase II Environmental Site Assessments

REPRESENTATIVE PROJECT EXPERIENCE

Mr. Welch has fourteen years experience in the environmental field. Mr. Welch has served as Project Manager/Project Geologist on assignments related to asbestos building inspections and abatement oversight, asbestos project design specifications, asbestos air monitoring, asbestos Operation and Maintenance (O&M) plans and training, assessment and remediation of contaminated soil and groundwater, Phase I Environmental Site Assessments and CADD design. His asbestos experience includes managing projects in Washington, Oregon, Idaho, Montana, Arizona and California. His geotechnical experience has been focused on state-equivalent RCRA, and UST programs in Washington, Oregon, California and Nevada. Mr. Welch has primary experience in hydrocarbon contamination but has also managed projects relating to mineral spirits, PCE, and lead. Mr. Welch has been involved with a variety of traditional and innovative remediation technologies, including pump and treat systems, vapor extraction, bio-enhanced vapor extraction, air sparging and aboveground bioremediation cells. Mr. Welch has experience in supervising drilling

assessment projects utilizing hollow stem auger, mud rotary and air rotary technology, and installation of groundwater monitoring wells, recovery wells, and vapor extraction wells.

Relevant Projects including Job Title and Job Responsibilities

- **Independent Remedial Action, Spokane, Washington** - Managed an Independent Remedial Action under MTCA on a former foundry site with extensive lead contaminated soils. Conducted subsurface characterization and remedial investigation on site. Collected data from quarterly groundwater monitoring program on site that indicated lead was not leaching into a shallow groundwater table within the zone of highest soil contamination. Cleanup alternatives were evaluated with a multi-layer impermeable cap and imposed institutional controls proposed for a long-term solution.
- **Subsurface Characterization/Remedial Action, Bellevue, Washington** - Assisted in field assessment, modeling and reports pertaining to a release of tetrachloroethane (PCE) into subsurface soils at a former dry-cleaning facility. The project was concurrent with a contracted development of the property into an upscale shopping center. The project underwent an IRAP coordinated with the Washington State Department of Ecology (WDOE).
- **System-Wide Asbestos Program, Major Railroad** - Conducted asbestos inspections, re-inspections, pre-design survey, CADD design, design specification manuals, project site management/air monitoring and building inspection reports for project sites in 22 states.
- **System-Wide Vermiculite Characterization and Removal Program, Major Railroad**—provided expertise in developing building inspections, pre-design surveys, CADD design, design specifications manuals, and project site management/air monitoring for managing vermiculite in 22 states.
- **Asbestos Management-Major Bank** - Project management, survey, design and project site management during removal of asbestos-containing materials at four bank branches undergoing remodel in the Puget Sound area. Work was conducted at night during off hours and had special security access protocols that were adhered to.
- **Asbestos Management - Truck Manufacturer** - Project management, facility survey, design specifications, Operation and Maintenance Plan, awareness training seminars at Seattle plant. Survey required lift access coordination and site safety considerations.
- **Asbestos Management - Multi-tenant Commercial Building Owner** - Project management, facility survey, design specifications manual, proposed Operation and Maintenance Plan and awareness training seminars. Survey was conducted for existing owner as part of an interested buyer's request. Project conducted concurrently with independent remedial action for this former bulk fuel terminal. Proposed multiple options and costs for asbestos management/removal depending on future site use.
- **Asbestos Management - Major Railroad** - designed and implemented a 16 hour Operation and Maintenance (O&M) training program tailored for structures and telecom personnel
- **Phase I ESA, Asbestos Building Inspection, Project Design Specifications and Project Site Management/Air Monitoring - Industrial Building Owner Partnership** - Conducted Phase I ESA/AHERA building inspection for design and removal of all friable asbestos-containing materials. The project was conducted within the proposed budget and schedule.

Robert D. Gilmore, C.I.H.

Principal, Certified Hygienist

Professional summary

Mr. Gilmore, a Certified Industrial Hygienist, has more than 25 years experience directing environmental science, industrial hygiene, and safety programs at various private and government installations. His duties have included direct project management, from conceptual design through remediation, of environmental contamination and hazardous materials abatement projects. He has expertise in OSHA, EPA, and other federal and state regulations governing the establishment of health, safety, and environmental protection programs. Mr. Gilmore has demonstrated management skills in program development and implementation; budgeting, marketing, and contract administration; profit/loss accountability; and personnel administration. His technical skills/experience include extensive regulatory compliance and litigation support consultation; management of projects up to \$20 million in construction costs and/or \$2 million in technical services; and development and instruction of technical training programs in environmental sciences. Mr. Gilmore has served as an expert witness in federal and state courts; he is frequently retained as an instructor and invited public speaker on environmental, health and safety issues; and has served as a technical resource in construction claim arbitrations regarding regulatory agency action and environmental impact claims. He has provided technical consultation services throughout the United States, including Alaska and Hawaii, and has traveled to and/or worked on construction projects in Canada, Mexico, South America, Europe, South Africa, and the Caribbean.

Professional qualifications

Certified in the Comprehensive Practice of Industrial Hygiene, American Board of Industrial Hygiene

U. S. Environmental Protection Agency, AHERA -accredited Asbestos Supervisor/Building Inspector/Management Planner/Project Designer

U.S. Department of Labor, OSHA Certified Instructor, OSHA Training Institute

State of Washington, Certified Asbestos Project Supervisor, Washington

Education

University of Washington, Seattle, Washington, M.A.Sc. Public Health and Industrial Hygiene, 1979

University of Washington, Seattle, Washington, B.A.Sc. Environmental Health, Minor Microbiology and Chemistry, 1972

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Memberships

American Academy of Industrial Hygiene (Diplomate)

American Industrial Hygiene Association

American Society for Testing and Materials

American Society of Safety Engineers

American College of Forensic Examiners

Health Physics Society

Association of Military Surgeons of the United States

Location

Kirkland, Washington

Employment history

1998 – Present: Senior Associate, AMEC Earth & Environmental, Inc.,

1997 – 1998: Director, Environmental Sciences, Garry Struthers Associates, Inc.

1996 – 1997: Certified Industrial Hygienist, Prezant Associates, Inc.

1987 – 1996: President/Principal, Environmental Health Sciences, Inc.

1986 – 1987: Director, Operations and Planning, Hanford Environmental Health Foundation, Inc./NHS, Inc.

1980 – 1987: Manager, Environmental Health Sciences Division, Hanford Environmental Health Foundation, Inc./NHS, Inc.

1979 – 1980: Corporate Industrial Hygienist, Union Carbide Corporation

1976 – 1979: Manager of Industrial Hygiene, Union Carbide Corporation

1974 – 1976: Industrial Hygienist, U.S. Atomic Energy Commission/United States Energy Research and Development Administration

Project Experience

Indoor Air Quality Services, Bellevue School District: Mr. Gilmore served as a technical consultant for the assessment of indoor air quality issues in elementary, middle school, and high school facilities. Services included monitoring indoor air quality for physical, chemical, and biological parameters; preparing technical reports; assisting in the assessment and mediation of claims; and recommending corrective actions when indicated.

Indoor Air Quality Services, Safeco Insurance Company: Mr. Gilmore served as a technical consultant for multiple projects involving claims for property damage and/or personal injury related to adverse indoor air quality. Typical projects involved assessment of mold and related biologicals following extensive water/moisture damage. Projects also involved testing for trace gaseous contaminants. Assigned tasks included review of consultant and engineering reports, claims, and litigation support.

Northgate Delta Building, Seattle, Washington: Mr. Gilmore was responsible to conduct an indoor air quality assessment at the Northgate Delta Building (Washington Dental Services). The assessment protocol included HVAC inspection and evaluation, general conditions walk-through, data logging monitoring for CO₂, CO, temperature, humidity, and PM10 particulate, as well as sampling for formaldehyde.

Underground Storage Tanks, Snohomish County Public Utility District: Mr. Gilmore served as the Project Manager and Senior Consultant for the environmental site assessment, conceptual design report, plans and specifications, permitting, and construction oversight for the removal, replacement and/or renovation of ten underground storage tanks (USTs) at a major urban operations center and one tank at a remote site in the Cascade mountains. The tanks served a major fuel dispensing operation (four tanks - 15,000 gallons each), transformer oil storage (three tanks B 6,000 gallons each), chemical waste storage (500 gallons), and stand-by emergency generators (280 and 1,000 gallons). The project included removal and replacement of the transformer oil tanks (including one stainless steel tank to meet unique product quality standards); inspection, renovation and upgrade of the fuel tanks; removal and closure of the waste tank site; closure of one emergency generator tank in-place and replacement with an aboveground storage tank (AST); and piping and filling upgrades to the remaining generator tank. Task included design of new fuel dispensing systems, card-lock control systems, liquid level monitoring systems, cathodic protection systems, and related structures and controls.

Superfund Site Redevelopment Project, Terminal 18 Redevelopment Company: Mr. Gilmore currently serves as the AMEC Project Manager for the oversight and technical services tasks associated with the demolition of over 130 structures and contaminated soils on this Superfund site. The Terminal 18 Redevelopment Project will increase the container cargo capacity of Terminal 18 on Harbor Island, Seattle, Washington, by expanding the area for container cargo marshalling, a water-dependent use, through redevelopment of adjacent industrial sites and by improving container handling efficiency through construction of improved and expanded intermodal rail facilities. The project is entirely located on Harbor Island and includes all of the existing Terminal 18; properties and rights-of-way proposed to be added to the terminal; properties proposed for public shoreline access, transportation improvements, and parking to support the marine terminal use; and improvements within public rights-of-way.

AMEC Earth & Environmental was retained as the prime environmental consultant, geotechnical engineer of record, and materials inspection and testing service provider for the Terminal 18 redevelopment project. AMEC is a prime sub-contractor to Morrison -Knudsen Corporation for this design/build project. AMEC is involved in all aspects of environmental work from planning to post-construction monitoring. The scope of environmental tasks includes health and safety technical services.

AMEC is responsible for technical services for environmental management, including permitting and approvals, geotechnical and materials engineering, site specific environmental protection plans,

quality assurance/quality control, aquatic/terrestrial habitat assessment and restoration, management of environmental remediation, public consultation/information, and post-construction monitoring.

AMEC is providing environmental management through a team of professionals dedicated specifically to the Terminal 18 Project. This assures continuity through planning, design, construction and monitoring phases of the project. A strategic regulatory liaison protocol has been established, promoting cooperative and constructive project review, and allowing the AMEC team to rapidly review and implement environmental mitigation measures B resulting in environmental protection with no delay in construction or costly overruns.

Expert Witness, McGavick Graves, PS: Mr. Gilmore served as an expert witness and technical consultant for the defendant in a litigation involving claims of negligence and personal injury to multiple employees in a plastic component manufacturing operation. He provided review of client records, regulatory agency inspections, consultant reports, claims, depositions and plaintiff experts. Prepared technical analysis of historical data, developed written reports of opinions, and served as an expert witness. Mr. Gilmore assisted in the identification, selection, and briefing of additional witnesses including medical experts and process/ventilation engineers.

Consultation and Technical Services for Asbestos, Berger/ABAM Engineers, Inc.: Mr. Gilmore served as a technical consultant for the assessment of work practices, procedures, and regulatory requirements for the removal of asbestos containing materials at a former U.S. Air Force Base being converted to use by the U.S. Bureau of Prisons. His tasks involved assessment and document development for a unique method of removal of asphalt impregnated asbestos in coating systems used on earth covered concrete ammunition bunkers that were to be demolished. Mr. Gilmore's tasks included negotiating work practice and waste disposal agreements with the local air pollution control authority and regional U.S. Environmental Protection Agency officer-in-charge. The successful completion of this project resulted in significant construction related cost savings to the U.S. Bureau of Prisons.

Consultation and Technical Services for Asbestos, R.W. Rhine, Inc.: Mr. Gilmore served as a technical consultant for the assessment of work practices, procedures, and regulatory requirements for the removal of asbestos, lead, and other regulated and/or potentially hazardous materials encountered in structural demolition projects. Typical projects included port facilities and urban multiple story buildings in high-visibility/high-risk areas such as hospital complexes. His tasks included work practice review, preparation of site-specific documentation including work plans, monitoring data review and approval, regulatory agency interface, and consultation with the owners of the structures.

Technical Training Services, Associated General Contractors, Multiple Projects: Mr. Gilmore developed and presented training programs in such construction related areas as asbestos abatement, fugitive dust controls, and environmental liability management. Programs were developed under grants by regulatory agencies and association members. Training sessions are presented on a regular basis throughout the state of Washington.

Compliance Audits/Program Reviews - US Department of Energy Facilities (Nationwide): Mr. Gilmore served as a lead compliance auditor and program reviewer of health, safety, and environmental protection activities at government-owned contractor-operated facilities involved in nuclear weapons assembly/disarmament, materials production, research and development, decommissioning and demolition, and environmental restoration. Facilities inspected included National Laboratories, uranium enrichment and fuel production complexes, strategic petroleum reserves, electronic manufacturing and assembly operations, construction sites, and environmental remediation demonstration sites. Facilities were located in Washington, Idaho, Nevada, California, New Mexico, Colorado, Ohio, Tennessee, Illinois, New York, South Carolina, Kentucky, Florida, Louisiana and Texas. This project included multiple task assignments over a five-year period, including assignment to "Tiger Teams" (investigative teams formed at the direction of the Secretary of Energy) engaged in comprehensive environmental, health and safety assessments. His tasks

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routinely included OSHA-type compliance inspections; process safety reviews; readiness and pre-occupancy reviews; permits and other regulatory compliance documentation review; program audits, policy and procedure reviews; and performance assessments.

University of Washington, OSHA Regional Training Center, Guest Instructor: Mr. Gilmore served as an instructor in OSHA 500: Trainer Course in OSHA Standards for the Construction Industry and OSHA 501: Trainer Course in OSHA Standards for General Industry. The courses were designed as “train the trainer” courses to enhance regulatory compliance within both general industry and construction.



J. Michael Harris, C.I.H.

Senior Project Manager

Professional summary

Mr. Harris is a senior-level consultant and project manager with over 19 years of quantifiable achievement. He has directed environmental projects and occupational safety and health programs for a diversified clientele including government agencies, military, aluminum manufacturing, aerospace, educational, commercial and industrial clients. His project experience has ranged from remediation of environmental hazards (including, but not limited to, arsenic, cadmium, hexavalent chromium, and mercury), to regulated materials abatement project design and management for large capital improvement projects. A certified industrial hygienist, Mr. Harris is also accredited in all AHERA disciplines.

Professional qualifications

Certified Industrial Hygienist #CP-8177

AHERA Project Designer, 1995

AHERA Building Inspector, 1987

AHERA Management Planner, 1987

40-Hour Hazardous Waste Operations and Emergency Response, 1994

Education

B.A., Chemistry, University of Hawaii, Manoa, 1983

Memberships

Diplomate, American Board of Industrial Hygiene

Location

Kirkland, Washington

Summary of core skills

Industrial Hygiene Services

Mr. Harris has served as a technical consultant for a variety of industrial hygiene issues. He has provided exposure-monitoring services for construction and industrial clients, as well as performed indoor air quality investigations and regulated materials surveys in schools, medical facilities, offices and private residences. Mr. Harris is expertly skilled at hazard recognition and development and application of control measures necessary to reduce exposures to identified hazards. Originally trained as an analytical chemist, Mr. Harris has a thorough understanding of field and laboratory test methods and sampling techniques that can be utilized for industrial hygiene investigations, providing the best data available for the concern at hand.

Hazardous Materials Management and Testing

Mr. Harris has participated in many diversified hazardous materials abatement projects, designed abatement plans, authored health and safety plans, and provided supervision of consultants and

J. Michael Harris

contractors during the execution of hazardous materials abatement. Projects Mr. Harris has participated in include: Removal of Ethylene Dibromide for Dole Pineapple, Oahu, Hawaii, Mercury Cleanup of Kalaupapa Lighthouse, Molokai, Hawaii, Hazardous Waste Cleanup of Honolulu Shipyard, Oahu, Hawaii, Removal of DDT from Auburn Social Security Office, Auburn, Washington, Whidbey Island Naval Shipyard Steam Plant Improvements, Oak Harbor, Washington, and numerous other asbestos, lead and PCB projects.

Industrial Materials Management and Planning

Mr. Harris is the Health and Safety Coordinator for the Seattle AMEC office. He oversees all aspects of health and safety during construction/demolition and hazardous materials abatement activities. Mr. Harris has written health and safety plans that cover all aspects of construction/demolition, manufacturing and industrial processes, Phase II site assessments and hazardous materials emergency response and abatement. Also a well-known environmental and occupational safety trainer, Mr. Harris has taught classes in all AHERA disciplines for asbestos, Hazard Communication, Hazard Waste Operations and Emergency Response, Lead Awareness, Silica Awareness and many other topics.

Employment history

2003 – Present: AMEC Earth & Environmental, Senior Project Manager, Kirkland, Washington

2000 – 2002 and 1993-1995: Med-Tox Northwest, CIH/Senior Project Manager, Auburn, Washington

1997 – 2000: Pacific Rim Environmental, Operations Manager, Tukwila, Washington

1996 – 1997: Shapiro and Associates, Industrial Hygienist, Seattle, Washington

1991 – 1993: Champion International Corporation, Safety Engineer, Canton, North Carolina

1985 – 1990: Pacific Marine, Ltd., Chemist/Operations Manager, Honolulu, Hawaii

1984 – 1985: INALAB, Laboratory Supervisor, Honolulu, Hawaii

Detailed core skills or details by project

Minne-Tohe Health Facility, New Town, North Dakota: Mr. Harris performed a comprehensive mold inspection of the Three Affiliated Tribes Minne-Tohe Health Facility and residential quarters. Results of this inspection resulted in the closing of one administration building due to high airborne fungi concentrations. Working with Indian Health Services (IHS), Mr. Harris developed specifications specific to mold abatement, developed budget estimates and contract design documents, as well as providing mold awareness training to IHS personnel.

Port of Seattle Capital Improvement Projects, SeaTac, Washington: As senior project manager, responsible for directing project monitors in their daily activities. Provided asbestos awareness training for Port employees, contractors and vendors. Tasked as hazardous materials project designer for Main Terminal Seismic Improvements Ticketing, Mezzanine, and Penthouse projects.

Space Needle Regulated Materials Abatement, Seattle, Washington: Mr. Harris served as the primary regulated materials (asbestos, lead, PCB's) consultant for The Space Needle, Inc. during demolition, renovation and new construction on the Plaza, Restaurant, and Observation Levels. Duties included conducting inspections for regulated materials, providing specifications and contract documents for the abatement of identified regulated materials, project oversight of abatement contractor activities, and project closeout documentation.

Alcoa Aluminum, Malaga, Washington: Mr. Harris performed a comprehensive facility-wide audit of asbestos-containing materials, as well as providing specifications and abatement contract oversight. Mr. Harris also provided Alcoa employees with site-specific asbestos awareness and hazard communication training as required by WISHA.

Asbestos Site Monitoring, Boeing, Aircraft, Everett, Washington: Mr. Harris provided onsite Phase Contrast Microscopy (PCM) for D&G Mechanical, Inc. during time-sensitive asbestos removal projects at Boeing's Paine Field Facilities. Responsible for collection of all contractor and quality control air sampling specific to asbestos removal, as well as daily documentation of contractor activities.

Hines Corporation, Bellevue, Washington: Mr. Harris led the regulated materials inspection team, provided regulated materials abatement specifications and contract drawings, and provided project oversight during the demolition of pre-existing structures for Hines Corporation's 112 @ 12th Project in Downtown Bellevue.

Ledcor Industries, Bellevue, Washington: Mr. Harris conducted regulated materials inspections, project design and project oversight for abatement of a fifty-six unit housing area scheduled for demolition to make way for a Costco Store on 38th Street in Tacoma. Onsite PCM analysis performed on this project, resulting in an increase of the demolition schedule.

Weyerhaeuser Corp., Everett, Washington: Mr. Harris directed the project monitors assigned to provide onsite PCM analysis during the demolition of the old Weyerhaeuser Corporation Pulp Mill in Everett, Washington. He also provided "alternate means of control plans" for the demolition of the 240-foot smoke stack covered with asbestos-containing materials.

Pulp and Paper Mill Modernization Project, Canton, North Carolina: Mr. Harris was responsible for contractor health and safety during a \$300-million renovation/construction project. Conducted air monitoring, inspections and investigations throughout the project area for a work force of up to 1,300 construction personnel. Approved contractor work plans, confined space entry permits, pipe breaking permits, performed post-abatement visual inspections, and quality control air monitoring for employee exposure to asbestos, lead, chlorine, chlorine dioxide, methyl mercaptans, sulfur dioxide, and other site-specific airborne hazards.